B. ASSESSMENT OF BLUEFISH
(SAW/SARC-41)

A report of the
ASMFC Technical Committee/Assessment Subcommittee, SAW-41

EXECUTIVE SUMMARY

Bluefish, *Pomatomus saltatrix*, is a migratory pelagic species found in most temperate and tropical marine waters throughout the world. Along the U.S. Atlantic Coast, bluefish commonly occur in estuarine and continental shelf waters. Bluefish are a schooling species that migrate in response to seasonal changes, moving north and inshore during the spring and south and offshore in the late autumn. The Atlantic bluefish fishery is believed to exploit a single stock or population of fish.

Bluefish is one of the most sought after species in the recreational fisheries along the Atlantic Coast. In 2004, recreational anglers along the Atlantic Coast harvested over 6.9 thousand metric tons (mt) of bluefish, second only to striped bass (11.7 thousand mt harvested). Recreational catch of bluefish has averaged over 19 thousand mt since 1982. Landings from the commercial bluefish fishery have been consistently lower than the recreational catch. Regional variations in commercial fishing activity are linked to the seasonal migration of bluefish. Bluefish are most abundant in the North and Mid-Atlantic from late spring to early fall, when the majority of commercial fishing activity for bluefish in these areas occurs. In the late fall and winter, bluefish move southward and landings peak in the South Atlantic region. Annually, the majority of commercial landings are taken in the Mid- and South Atlantic regions where approximately 87% of the coastwide total landings have occurred since 1950.

The Atlantic States Marine Fisheries Commission (ASMFC) and the Mid-Atlantic Fisheries Management Council (MAFMC) jointly manage bluefish under Amendment 1 to the Bluefish Fishery Management Plan (FMP). The FMP defines the management unit as bluefish occurring in U.S. waters of the western Atlantic Ocean and is considered a single stock of fish. The FMP allows a state-by-state commercial quota system and recreational harvest limit to reduce fishing mortality. ASMFC and MAFMC adjust both quotas annually by the specification setting process. Overfishing definitions are based on F_{msy} and B_{msy}.

The Bluefish Technical Committee examined the quality of the commercial, recreational, and age data for use in an analytical model. The committee felt the level of sampling by gear and market grade from North Carolina and Virginia was adequate to characterize the length distribution of Atlantic coast bluefish landings. The level of commercial sampling in certain time periods was low, however the committee felt there was enough information covering the entire time series to capture the trends in size for landings since 1982. The Committee concluded that the recreational landings information was adequate for use in a bluefish assessment. Recreational discard estimates were also sufficient although there remains a lack of discard length information. Age information, although relatively sparse in some years, was determined adequate to characterize bluefish catch and indices.

The Committee decided an age-structured model was the best approach given the available data and suggestions from previous SAW reports. The committee felt that a VPA model produced satisfactory results, but the assumption of no error in the catch-at-age matrix and the ADAPT method of modeling selectivity could produce misleading results. Therefore, a catch-at-age model, ASAP from the NFT models, was used as the primary assessment tool. The ability of the ASAP model to allow error in the catch-at-age as well as the assumption of separability into year and age components makes it better suited to handle the selectivity patterns and catch data from the bluefish fishery.

The biological reference points established in Amendment 1 were based on the results of a biomass-dynamic model, ASPIC, which had been used to assess the bluefish stock in the past several years. New reference points are proposed based on the results of the catch at age model. The model software estimates $F_{msy} = 0.19$. Biomass reference points were developed by applying ASAP model results to a Thompson-Bell Yield-Per-Recruit model. The Shepherd-Sissenwine approach was used to estimate B_{MSY} at 147.05 million lbs; the current estimate of bluefish stock biomass is 104.1 million lbs. The ASAP model estimated F_{MULT} in 2004 to equal 0.149. The ASAP model results lead to the conclusion that the Atlantic stock of bluefish is not experiencing overfishing. The current FMP defines an overfished condition as ½Bmsy which equals 73.5 million lbs. The current biomass estimate implies that bluefish are not overfished.

1.0 TERMS OF REFERENCE

1. Evaluate adequacy, appropriateness, and uncertainty of fishery-dependent and fishery-independent data used in the assessment.
2. Evaluate adequacy and appropriateness of models used to assess the stock and to estimate population benchmarks.
3. Evaluate and/or update biological reference points as appropriate.
4. Estimate and evaluate stock status (biomass) and fishery status (fishing mortality rates).
    a. Is the stock overfished?
    b. Is overfishing occurring?
5. Develop recommendations for improving data collection and for future research.

2.0 INTRODUCTION

The Atlantic States Marine Fisheries Commission (ASMFC) and Mid-Atlantic Fishery Management Council (MAFMC) jointly developed the Fishery Management Plan (FMP) for the bluefish fishery and adopted the plan in 1989 (ASMFC 1989; Moore 1989). The

Secretary of Commerce approved the FMP in March 1990. The FMP defines the management unit as bluefish (*Pomatomus saltatrix*) in U.S. waters of the western Atlantic Ocean.

The ASMFC and MAFMC approved Amendment 1 to the FMP in October 1998 and the National Marine Fisheries Service (NMFS) published the final rule to implement the Amendment 1 measures in July 2000 (MAFMC and ASMFC 1998). Amendment 1 implemented an annual coastwide quota to control bluefish landings. The ASMFC and MAFMC adjust the quota and harvest limit annually using the specification setting process detailed in Amendment 1. The recreational fishery is allocated 83% of the entire quota. Coastwide, the commercial fishery is limited to 17% of the total allowable landings each year. The commercial quota can be increased if it is anticipated that the recreational fishery will not land their entire allocation for the upcoming year. The coastwide commercial quota is divided into individual state-by-state quotas based on landings from 1981-1989.

2.1 Life History

Bluefish, *Pomatomus saltatrix*, is a coastal, pelagic species found in temperate and tropical marine waters throughout the world (Goodbred and Graves 1996; Juanes et al. 1996). Bluefish spawn in offshore waters (Kendall and Walford 1979; Kendall and Naplin 1981). Larvae develop into juveniles in continental shelf waters and eventually move to estuarine and nearshore shelf habitats (Marks and Conover 1993; Hare and Cowen 1994; Able and Fahay 1998; Able et al. 2003). Bluefish are highly migratory along the U.S. Atlantic coast and are found north of the Carolinas only in warmer months (Beaumariage 1969; Lund and Maltezos 1970).

2.2 Growth

Several studies show bluefish to be a moderately long-lived fish with a maximum age of 14 years (Hamer 1959; Lassiter 1962; Richards 1976; Barger 1990; Chiarella and Conover 1990; Terceiro and Ross 1993; Austin et al. 1999; Salerno et al. 2001; Sipe and Chittenden 2002). Bluefish up to 88 centimeter (cm) fork length (FL) have been aged (Chiarella and Conover 1990; Salerno et al. 2001). Terceiro and Ross (1993) noted considerable variation in mean bluefish size-at-age. Scale ages have been used to estimate von Bertalanffy growth parameters (Lassiter 1962; Barger 1990; Terceiro and Ross 1993; Salerno et al. 2001). The values for L_∞ from these studies (87-128 cm FL) match closely to the largest individuals in catch data. Growth rates do not differ between sexes (Hamer 1959; Salerno et al. 2001).

Bluefish grow nearly one-third of their maximum length in their first year (Richards 1976; Wilk 1977). Variation in growth rates or size-at-age arise among young bluefish from the appearance of intra-annual cohorts. Lassiter (1962) identified a spring-spawned cohort and a summer-spawned cohort from the bimodal appearance of size at Annulus I for fish aged from North Carolina. As the cohorts appellations imply, the seasonal cohorts differ in age by two to three months. Summer-spawned larvae and juveniles grow faster than spring-spawned larvae and juveniles (McBride and Conover 1991). Size differences at annual age diminish greatly after three to four years (Lassiter 1962).

2.3 Reproduction

Bluefish spawn offshore in the western North Atlantic Ocean, from approximately Massachusetts to Florida (Norcross et al. 1974; Kendall and Walford 1979; Kendall and Naplin 1981; Collins and Stender 1987). In addition to the spring and summer cohorts identified by Lassiter (1962), Collins and Stender (1987) identified a fall-spawned cohort, demonstrating an expansive and prolonged bluefish spawning season. Individual bluefish are thought to be highly iteroparous but no specific information is published for spawning frequency or batch fecundity.

2.4 Stock Definitions

Bluefish in the western North Atlantic is managed as a single stock (NEFSC 1997; Fahay et al. 1999). Genetic data support a unit stock hypothesis (Graves et al. 1992; Goodbred and Graves 1996; Davidson 2002). For management purposes, the ASMFC and MAFMC define the management unit as the portion of the stock occurring along the Atlantic Coast from Maine to the east coast of Florida.

2.5 Habitat Description

Adult and juvenile bluefish are found primarily in waters less than 20 meters (m) deep along the Atlantic coast (Fahay et al. 1999). Adults use both inshore and offshore areas of the coast and favor warmer water temperatures although they are found in a variety of hydrographic environments (Ross 1991; Fahay et al. 1999). Temperature and photoperiod are the principal factors directing activity, migrations, and distribution of adult bluefish (Olla and Studholme 1971).

3.0 DESCRIPTION OF FISHERIES

3.1 Commercial Fishery

Commercial landings from the bluefish fishery have been consistently lower than the recreational catch (Table 1; Figure 1). Gill nets are the dominant commercial gear used to target bluefish and account for over 40% of the bluefish commercial landings from 1950 to 2003. Other commercial gears including hook & line, pound nets, seines, and trawls, collectively account for approximately 50% of the commercial landings.

Regional variations in commercial fishing activity are linked to the seasonal migration of bluefish. The majority of commercial fishing activity in the North and Mid-Atlantic occurs from late spring to early fall when bluefish are most abundant in these areas. As water temperatures decrease in late fall and winter, bluefish migrate south. Peak landings in the South Atlantic occur in late fall and winter. The majority of commercial landings are taken in the South and Mid-Atlantic regions (Table 2). Since 1950, approximately 87% of the coastwide total landings have been taken in these regions.

Commercial landings decreased from 7,500 mt in 1981 to 3,300 mt in 1999 (Table 1; Figure 1). Commercial landings have been regulated by quota since implementation of Amendment 1 in 2000. In 2000 and 2001, landings increased to approximately 3,600 mt and 3,900 mt, respectively, but declined again in 2002 and 2003 to at 3,100 mt and 3,400 mt, respectively (Table 1; Figure 1). Preliminary landing estimates for 2004 increased to 3,800 mt (Table 1).

3.2 Recreational Fishery

Bluefish is a highly sought after species in the recreational fisheries along the Atlantic Coast. Recreational catch of bluefish has averaged over 19,000 metric tons (mt) since 1981 (Table 1, Figure 2). In 2004, recreational anglers along the Atlantic Coast harvested over 6,800 mt of bluefish. Most of the recreational activity occurs from July to October, when almost 70% of the bluefish harvest is taken (Figure 3) . Most of the recreational catch of bluefish is taken in the North and Mid-Atlantic states (New York to Virginia) (Table 3). Recreational landings decreased from 43,500 mt in 1981 to a low of 5,379 mt in 1999. Since 1999, landings and numbers have fluctuated from about 6,200 mt to about 8,000 mt. Landings in 2004 were 6,870 mt (Table 1; Figure 2).

4.0 TERM OF REFERENCE #1: Evaluate adequacy, appropriateness, and uncertainty of fishery-dependent and fishery-independent data used in the assessment.

This bluefish assessment is an extension of the stock analysis reviewed in 1997 and accepted at SAW-23. The Bluefish Stock Assessment Working Group therefore concluded that information through 1995, the final year in the SAW-23 assessment, was adequate for use in an age-based assessment model. Expanded numbers at length for commercial and recreational fisheries were subsequently updated through 1996. Data from 1997 to present were assembled and reviewed for adequacy by the current working group.

4.1 Commercial Data

Commercial fisheries landings data for states between North Carolina and Maine are collected via the NMFS dealer mandatory reporting system. Beginning in June 2004, an electronic dealer reporting was initiated in the northeast. The states of Florida, Georgia, and South Carolina use a trip ticket system.

4.1.1 Commercial Biological Sampling

Commercial length data from 1997 to 2004 were expanded based on four regions of sampling: Maine to Maryland, Virginia, North Carolina, and South Carolina to Florida.

4.1.1.1 Maine to Maryland

Biological samples collected by NMFS were used to expand landings by year, quarter, gear, and market category. Length data were measured to the nearest cm FL and total landings in weight in pounds (lbs). Lengths were converted to weights using a seasonal length-weight equation across all years. Missing information in cells was replaced by mean weights in adjoining cells (e.g. among gears by market category, quarter). If no appropriate information was collected within a year, overall cell mean weights were substituted from the 1997 to 2004 period.

Sampling levels, landings and samples per 100 lbs of landings are presented in Tables 4 to 6. Since 1997, sampling in this region has averaged only 1,766 lengths per year (1,376 excluding the 4,500 lengths from 2004). The seasonal distribution of samples varied by year, although in general few samples were collected during the first quarter. Similarly, all market grades were not sampled equally among seasons or years.

4.1.1.2 Virginia

The Virginia Marine Resources Commission's (VMRC) Stock Assessment Program (SAP) has collected finfish biological data (length, weight, sex, and age) since 1988. At most sites, bluefish are sampled from 50-pound boxes of landed fish that have been graded, boxed, and iced. At sites associated with pound net or haul seine landings, bluefish are intercepted after they have been graded by market category and weighed. A 50-pound box (or partial box) of graded fish from all available species market categories (*i.e.* small, medium, large, and unclassified) are chosen for determination of length, weight, and sex information. In most cases, the entire 50-pound box of fish graded by species market category is sampled to account for within-box variation (see Chittenden et al. 1990).

Each fish is measured for size (total length and usually weight). Weight is measured to the nearest 0.1 lbs; total length is measured to the nearest millimeter (mm), accurate to 2.5 mm, using electronic Limnoterra Fish Measuring Boards. Fork length is measured on a subsample basis. All fish, except those with damaged tails, are measured for total length from the tip of the snout to the end of the tail fin.

Ancillary data collected for each biological sample includes species grade or market category, harvest area, gear type used, and total catch by species market category. Biological data collections are generally stratified by season, area, gear type, and market grade. Numbers of fish sampled depends on availability but range from roughly 5,000 (1989-1992) to about 2,000 (2000-2003). Sampling intensity ranged from 25.8 lbs per 1,000 lbs of landings (2003) to 4.5 lbs sampled per 1,000 lbs of landings (1995) from 1989 to 2003. Generally, a greater proportion of the landings are sampled during years of lower landings. A summary of samples collected, landings and sampling per unit weight are provided in Tables 4 to 6.

4.1.1.3 North Carolina

Commercial bluefish landings are monitored through the North Carolina trip ticket program (1994-present) (NCDMF 2004). Under this program, licensed fishermen can only sell commercial catch to licensed North Carolina Division of Marine Fisheries (NCDMF) fish dealers. The dealer is required to complete a trip ticket every time licensed fishermen land fish. Trip tickets capture data on gears used, area fished, species harvested, and total weights of each individual species landed, by market grade. Trip tickets are submitted to NCDMF monthly.

Fishery-dependent sampling of NC commercial fisheries has been ongoing since 1982. Predominant gears sampled include: ocean sink nets, estuarine gill nets, winter trawls, long haul seines/swipe nets, beach haul seines, and pound nets. From the fishery-dependent data, NCDMF derives length and weight estimates by market grade for almost all of the commercial landings except catches by shrimp trawls, pots, long line, gigs, fyke nets, hand harvest, trolling, and rod & reel. Landings from these unsampled or 'other' commercial gears combined represent 0.2-1.1% of the 1997-2004 landings. Length frequency distributions from all sampled commercial gear were combined to represent landings by these other gears.

Bluefish length frequency samples, by gear, for both the market and bait components were obtained from dealers with a sample representing the landings from an individual trip. Sampling was done by market category as fish were culled at the dealers. Length distributions (and aggregate weights) from sampled trips by gear and market grade were expanded by respective landings, gear, and market grade. Length frequency distributions were combined to represent total landings, by gear, market grade, quarter, and year.

Length frequency distributions, by gear, market grade, quarter, and year, were used to proportion the total number of individuals harvested into numbers at length. Due to the lack of available data for the jumbo market grade, large and jumbo market grades were combined. When length information was insufficient, data from bluefish caught from inside waters by long haul seines, estuarine gill nets, or pound nets, or the ocean beach seine fishery, were substituted for each other.

Bait was defined as the part of the catch not marketed for human consumption, but sold for crab or fish pot bait, industrial uses, or discarded. Bait landings were estimated bi-annually by applying the bi-annual ratio of marketable to bait species sampled in the fish house to the reported marketable landings. The total number of bait individuals by fishery was derived by dividing the estimate of bait landings by the mean weight of a bait individual for each fishery, for each bi-annual period. A summary of samples collected and sampling per unit weight are provided in Tables 4 to 6. Since 1997, NC has averaged 7,650 length measurements per year covering all seasons and market grades.

4.1.1.4 Florida

Biological data collection for the bluefish fishery from Florida to North Carolina was sparse. Florida Department of Environmental Protection (FLDEP) collected 724 lengths from a variety of gear types since 1998 (although 4,321 fish were measured between 1993 and 1997 prior to a change in fishery regulations). The length distribution among periods was similar to NC medium grade bluefish, consequently the NC medium length distribution was used to expand semi-annual FL landings (Figure 4).

Expanded commercial fisheries length frequencies among all sampling programs are presented in Figure 5.

4.2 Commercial Discards or Bycatch

The SAW-23 assessment concluded that commercial discards were minimal and not estimable based on available data. The bluefish stock assessment working group concluded that discard estimates for the Atlantic coast were not possible and likely insignificant for several reasons. First, there is no minimum fish size in the commercial fishery. Second, the average commercial quota for the 1994-2003 period was approximately 10 million lbs while an average 8.1 million lbs was landed in the same time period. Third, the bluefish FMP allows states with a surplus quota to transfer a portion or the entire quota to a state that has or will reach its quota. Finally, Amendment 1 allows quota transfer from the recreational fishery to the commercial fishery.

4.3 Recreational Data

Recreational fishery statistics for bluefish caught along the Atlantic Coast were obtained from the Marine Recreational Fisheries Statistics Survey (MRFSS). The MRFSS estimates are divided into three catch types:

1) Fish brought to the dock in whole form and are identified and measured by trained interviewers are classified as landings (Type A).
2) Fish that are not in whole form (*e.g.* bait, filleted, released dead) when brought to the dock are classified as discards (Type B1). Discards are reported to the interviewer but identified by the angler.
3) Fish released alive (Type B2) are identified by the angler and reported to the interviewer.

The sum of types A and B1 provides an estimate of total harvest for the recreational fishery. Total recreational catch is the sum of the three catch types (A + B1 + B2). Estimates of weight provided by MRFSS are minimum values and may not accurately reflect the true total weight that was landed or harvested. This bias is more common with large or rarely caught species.

Length and weight measurements of type A catch are collected as part of the MRFSS intercept survey program (Figure 6). The intercept survey collects catch and demographic information from recreational anglers who have just completed fishing. Sampling is stratified by state, mode (shore, private/rental, or charter/party), and two month wave, with a minimum of 30 intercepts per stratum. Numbers, weights, and lengths are recorded by species as part of the intercept interview. The intensity of length frequency sampling for bluefish from the recreational fishery was calculated on the basis hundreds of pounds landed per length measurement (NEFSC 1994a, 1994b, 1997). Sampling intensity by wave is presented in Table 7 for 1997 to 2004. Because there is no minimum size, the working group assumed that bluefish recreational discards had the same size distribution as landed fish. As in previous bluefish stock assessments, a discard mortality rate of 15% was assumed for type B2 catches based on Malchoff (1995) and as modified by the ASMFC Bluefish Technical Committee (NEFSC 1997).

4.3.1 Recreational Catch Rates

The MRFSS intercept and catch estimate data were used to develop a fishery-dependent time series of catch-per-unit-effort (CPUE). Recreational fishing effort was defined as those trips that either caught or targeted bluefish (*i.e.* variable 'PRIM1' or 'PRIM2' in MRFSS intercept files). Bluefish catch was also divided by the number of participants per trip to produce catch per angler trip as a measure of effort. The different measurements of effort had little effect on the time series trends (Figure 7). Based on the recommendation of previous SARC reviews, the CPUE time series was modeled in a general linear model framework using a negative binomial transformation of log catch rates (per trip) (Terceiro 2003). Significant variables in the model include year, wave, area, mode of fishing, and number of fishing days in the previous 12 months as recalled by anglers. Re-transformed year estimates from the GLM model were used as the recreational CPUE time series. A comparison of CPUE series before and after GLM modeling is shown in Figure 7. The amount of information available as covariates in the GLM is limited and has had little influence on the time series. .

4.3.2 Age Data

NCDMF age data were available for bluefish aged by scales (1983-1996; n=5,639) and otoliths (1996-2000; n=2,067). The majority of the age structures were collected from fishery-dependent sampling, but a few recreationally caught bluefish were also aged. Age data were also provided for age structures (scales, whole, and sectioned otoliths) collected from various northeast states (1996; n=295). The northeast samples were collected from commercial and recreational gear (hook & line, trawl, seine, and gill nets).

In 1997, VMRC established a cooperative fish ageing lab with Old Dominion University's Center for Quantitative Fisheries Ecology (CQFE) Laboratory. The CQFE Lab age harvest from Virginia's marine fisheries and provide the data to VMRC for management purposes. Otolith-based age data were available for bluefish from 1998-2004. Collection of age samples was based on a quota by inch interval. The Virginia time series (1998-2004) contains age information by gear, sex, market category, and location from approximately 2,500 samples, from sectioned otoliths only.

The bluefish stock assessment working group reviewed the NC age data and concluded that there was a shift in ageing protocol after 1997. From 1998 on, the time of annuli formation appears to be the criteria for birth date rather than January 1. Consequently the spring age data from 1998-2004 were incompatible with other available age data and could not be modified without supplemental information. Therefore, only age keys provided by VA from 1998 to 2004 were applied to commercial and recreational fisheries.

Several studies document the problems with bluefish ageing information, specifically problems with using scales to accurately age bluefish. False annuli, rejuvenated scales, identifying annuli on scales from larger fish, different annuli counts between scales from the same fish, and the timing of the first annulus formation can all cause inaccuracies (Lassiter 1962; Richards 1976; NCDMF 2000). The divergence between scale ages and otolith ages occurs beyond age-6 (E. Robillard, CQFE, pers. comm. 2005). Therefore the catch-at-age matrices were truncated to a 6+ category to reduce ageing error associated with scale ages in the 1982-1997 time period.

The SAW-23 review expressed concern that use of a single age key collected in NC may not be representative of the coastal stock (NEFSC 1997). Salerno et al. (2001) examined age data collected along the Atlantic coast in the NEFSC autumn trawl survey and compared the scale ages with the North Carolina commercial ages and concluded that the NC ages were representative of Atlantic coast bluefish. Other studies have used age-length information from commercial and recreational fisheries and fishery-independent surveys and have shown similar bluefish growth parameter estimates from Maine to North Carolina, providing further evidence that North Carolina age data are representative of the Atlantic Coast (VMRC 1999, 2000, 2001).

In years with a limited number of ages available, seasonal age keys were combined across years. Spring age keys were developed for 1997 (n=228), 1998-2001 combined

(n=62), 2002 (n=282), and 2003 (n=226). Spring 2004 (n=41) was a combination of 2003 and 2004 (Table 8). Fall age keys were developed for 1997 (n=217), 1998-1999 combined (n=337), 2000-2001 combined (n=412), 2002 (n=395), 2003 (n=214), and 2003-2004 combined (n=380) (Table 8). To fill gaps in the keys, the working group assumed that length bordered by lengths with only one age group were similar. Lengths with no available information were filled from an age key for the combined 1997-2003 period. Indices were divided by age using survey specific age data if available (CT 1984-1998 and NMFS 1997-1998), otherwise the general age key was applied.
Commercial catch at age and recreational catch at age were combined for the 1982 to 2004 catch at age matrix (Table 9). Age data was also used to calculate mean weights at age (Table 10). Recreational CPUE estimates were also partitioned into ages (Table 11) based on the proportion of each age group in the recreational catch at age matrix

4.4 Fishery-Independent Surveys

Fishery-independent surveys from Florida to New Hampshire were reviewed for this assessment. Survey methods include estuarine and nearshore bottom trawl and beach seine surveys. The surveys caught predominantly age-0 and age-1 bluefish (< 30 cm FL). Bluefish catch was generally low and large catches were sporadic. Indices of relative abundance were calculated based on constraints of catch size, time, and location of sampling. Several surveys sample monthly or bi-monthly. The working group evaluated the timing of each survey and chose the period that had the highest availability of bluefish to the survey gear (Table 12).

4.4.1 Northeast Fisheries Science Center (NEFSC) Fall Inshore Trawl Survey

The NEFSC has conducted bottom trawl surveys over a large portion of the Atlantic shelf since 1963 (Avarovitz 1981). Sampling sites are randomly selected from within depth-defined strata; both inshore and offshore strata are sampled. The surveys run in the spring, fall, and winter seasons. The surveys cover areas from 5 to 200 fathoms deep, from Cape Hatteras, North Carolina to Canadian waters. The trawling locations are allocated according to a stratified-random sampling design. Strata 1-46 are assigned to the fall inshore survey for stations from Cape Hatteras to Cape Cod. The research vessels F/RV *Albatross IV* and the F/RV *Delaware II* are used exclusively to conduct these surveys. A small-mesh cod-end liner (1/2 inch mesh) is used to retain pre-recruits. Bluefish are seen more commonly in the fall survey and from inshore sites. Mean number per tow and mean weight per tow from the 1975-2004 fall inshore survey were calculated (Table 13; Table 14). Mean number per tow at length since 1982 were divided into age categories using NEFSC ages prior to 1996 (Table 15). Age keys developed from VA data were used for 1997 to 2004. The majority of bluefish caught in the fall are age-0 or age-1. The index shows a large cohort present in 1981, 1984, and 1989. The index has been well below the time series average since 1989, although the 2003 index was slightly above average (Table 13).

4.4.2 NEFSC Fall Offshore Trawl Survey

NMFS fall survey data from 1975 to 2004 were also used to calculate stratified mean number per tow and mean weight per tow (Table 13). Age expansion was done as discussed for the inshore strata (Table 15). Catch rates in the offshore strata were considerably lower and varied without trend.

4.4.3 Massachusetts Division of Marine Fisheries Inshore Bottom Trawl Survey

The Massachusetts Division of Marine Fisheries (MADMF) started sampling inshore state waters in 1978 using a bi-annual seasonal bottom trawl survey. The survey design is random stratified using strata based on geographic area and depth zone. Bluefish are rarely observed in the spring component of the survey and the majority of bluefish caught during the fall survey are young-of-year (<25 cm), with most catches representing the second or summer cohort fish. Arithmetic and geometric mean numbers and length frequencies for young-of-year are available for the 1978 to 2003 time period. Survey indices depict larger than average year-classes in 1987, 1991, 1997, and 1998. Recent year-class indices (2000-2002) are lower than average (Table 13).

4.4.4 Rhode Island Marine Fisheries Trawl Surveys

The Rhode Island Division of Fish and Wildlife's (RIDFW) Marine Fisheries Section initiated a seasonal trawl survey in 1979 to monitor recreationally important finfish stocks in Narragansett Bay, Rhode Island Sound, and Block Island Sound. The survey employs a stratified random, stratified fixed design and records aggregate weight by species, abundance, individual length measurements, and various physical data. In 1990, a monthly component was added to the survey, which includes 13 fixed stations in Narragansett Bay. Abundance indices were calculated from 1981-2004.

Age-0 fish dominate bluefish catch in the RIDFW seasonal survey during the fall component of the survey. The spring component rarely catches bluefish. The average abundance index for the RIDFW survey was 14.1 fish/tow. Relative abundance was below average from 1981-1993, ranging from 1.3 to 13.0 fish/tow. Relative abundance was highest in 1994 (36.9 fish/tow), 1997 (72.2 fish/tow), 1998 (46.7 fish/tow), and 1999 (61.2 fish/tow) before dropping to below average in the early 2000s. The lowest abundance index occurred in 2003 (0.9 fish/tow) and the most recent index (2004) is below average at 5.5 fish/tow (Table 13; Table 14).

4.4.5 Connecticut DEP Long Island Sound Trawl Survey

The Connecticut Department of Environmental Protection's (CTDEP) Marine Fisheries Division has conducted the Long Island Sound Trawl Survey (LISTS) since 1984. The LISTS was designed to collect long-term fishery-independent data from the Connecticut and New York waters of Long Island Sound. The LISTS employs a stratified-random sampling design using strata based on depth interval (0-9.0 m, 9.1-18.2 m, 18.3-27.3 m or, 27.4+ m) and bottom type (mud, sand, or transitional). Sampling is currently divided into spring (April, May, and June) and fall (September and October) periods. Forty tows are sampled monthly (120 in the spring, 80 in the fall) using a 14 m otter trawl (9.1 m headrope, 14 m footrope). Species are sorted, weighed, and counted and all or a sub-sample of primary species are measured to nearest cm FL. Scales are removed from a sub-sample for ageing purposes. The LISTS has not aged bluefish since 1988, however, scales from 2,469 bluefish were collected and aged from 1984 to 1988. Geometric mean number per tow estimates were developed from the September tows as an index of bluefish abundance. Mean number per tow at age since 1988 were developed using NC or VA age keys (Table 15).

The LISTS has collected 150,091 bluefish from 4,869 tows since 1984. The survey is one of the few inshore state fishery-independent surveys that consistently capture adult bluefish during the fall period. The LISTS calculates two geometric mean count and weight indices for the fall survey: an age-0 index (fish less than 30 cm) which average 17.37 bluefish (2.34 kg/tow) and an age-1+ index which averages 3.60 fish per tow (5.71 kg/tow). The surveys age-0 abundance initially was low during the startup years of the survey then varied around average levels from the late 80s to 1996. A three-year period of high abundance was observed from 1997 to 1999 after which abundance decreased to average levels. The age-1+ bluefish index declined steadily from above average levels in 1985 to 1.92 fish/tow in 1989. A large increase in abundance was seen in 1990 and again in 1992. A precipitous decline occurred for the next seven years to 0.86/tow in1999, the lowest abundance recorded. Abundance of age-1+ bluefish increased for the next three years to average levels in 2002. However, recent large catches of adult bluefish during the fall of 2004 resulted in a 21-year record high abundance (in numbers) that was five times higher than that seen just a year earlier and the second highest biomass index in the survey (Table 13; Table 14). Many of these fish ranged from 37 cm to 41 cm FL, however, catches of fish up to 70 cm FL were common in 2004.

4.4.6 New York DEC Small Mesh Trawl Survey

The New York Department of Environmental Conservation's (NYSDEC) Small Mesh Trawl Survey started in 1987. The survey area is divided into 77 sampling blocks located in the Peconic estuary in eastern Long Island. Each year from May to October, sixteen stations are randomly chosen each week and sampled by an otter trawl (16 foot shrimp trawl with small mesh liner) and towed for 10 minutes.

Catches of bluefish, which peak in August and September, consist almost entirely of young-of-the-year (52 to 250 mm FL). The highest observed catches occurred in the late 1980s, with a smaller peak in the mid-1990s. Catches of young-of-the-year have been well below average and declining in recent years (Table 13). A geometric mean number per tow was calculated from August and September tows as an index of bluefish abundance.

4.4.7 New York DEC Beach Seine Survey

In 1984, the NYSDEC initiated a beach seine survey, which was designed to target age-1 striped bass. The survey uses a 200 foot beach seine to sample about 175 sets per year from May through October at fixed stations within western Long Island bays, primarily Little Neck, Manhasset, and Jamaica bays.

Catches of bluefish are predominantly young-of-the-year and usually reach their highest abundance in July and August. An index of bluefish abundance was based on August hauls. Catches of young-of-the-year were highest in the late 1980s, 2000, and 2001. Catches of young-of-the-year have been below average in 2003 and 2004 (Table 13).

4.4.8 New Jersey DFW Ocean Stock Assessment Program

The New Jersey Division of Fish and Wildlife (NJDFW) Bureau of Marine Fisheries initiated the Ocean Stock Assessment Program in 1989 to monitor the abundance and distribution of marine recreational fishes in the state's nearshore coastal waters. The survey uses a stratified random design and is conducted five times per year in January, April, June, August, and October. The survey samples waters from Sandy Hook to the entrance of the Delaware Bay.

Typically, few to no bluefish are collected during the January and April surveys. Annual numbers of bluefish per tow range from 0.3 to 10.6. The highest years of abundance were 1989 (10.6 bluefish per tow), 1994 (8.1), and 2002 (7.8). The lowest years of abundance were 2001 (0.3) and 1993 (0.9). Sizes range from 3 to 81 cm FL. The majority (75%) of bluefish were less than 31 cm FL. Indices of bluefish abundance and biomass was calculated as the geometric mean per tow from the October data (Table 13; Table 14). Indices were further divided into age groups by applying the generalized age keys to survey length data (Table 15). Indices at ages greater than 2 prior to 1998 were unavailable.

4.4.9 Delaware DFW Juvenile Trawl Survey

Delaware's Department of Natural Resources and Environmental Control (DNREC) Division of Fish and Wildlife's juvenile trawl survey targets juvenile fish and shellfish. This program was initiated in 1980 to monitor distribution, relative abundance, and year-class strength. The survey conducts monthly sampling from April to October at fixed stations in the Delaware Bay and River. Tows conducted during September were used to estimate an index of abundance as the geometric mean number per tow (Table 13).

4.4.10 Delaware DFW Adult Trawl Survey

The DNREC Division of Fish and Wildlife began an adult trawl survey in 1966. The survey was discontinued in 1971, started again in 1979, discontinued after 1984, and finally resumed again in 1990. The aim is intended to track temporal trends in abundance and distribution and to characterize the size composition of select species. Trawl tows are carried out monthly from March to December at fixed stations in the Delaware Bay. Large numbers of bluefish are not common, but bluefish do occur in the catches, peaking in the fall. Tows from August to October were used to calculate the geometric mean number per tow and biomass per tow as indices of bluefish abundance (Table 13; Table 14). Abundance indices were further divided into age groups (Table 15). Only fish age 0 to age 2 were included due to samples sizes.

4.4.11 Maryland DNR Juvenile Striped Bass Seine Survey

The Maryland Department of Natural Resources' (MD DNR) Juvenile Striped Bass Seine Survey has documented annual year-class success and relative abundance of many fish species in Chesapeake Bay since 1954. Juvenile striped bass indices are developed from sampling at 22 fixed stations located in major spawning areas in Maryland's portion of the Chesapeake Bay. A subset of 13 sample sites was selected for the development of a juvenile bluefish index from 1981 to present. Other sites were excluded on the basis that bluefish were rarely, if ever, captured there. Each site is visited monthly, from July to September, and two samples are collected.

Samples are collected with a 30.5 m x 1.24 m bagless beach seine of untreated 6.4 mm bar mesh set by hand. Selected fish species are separated into age-0 and age-1+ groups. Ages are assigned from length frequencies and verified through scale examination. A random sub-sample of 30 age-0 fish is measured per site, per month. All other finfish are identified to species and counted. Additional data collected at each site include: time of first haul, maximum distance from shore, surface water temperature, surface salinity, primary and secondary bottom substrates, percent submerged aquatic vegetation, dissolved oxygen, pH, and turbidity.

Effort was slightly variable prior to 1994 because sites were occasionally lost to beach erosion, bulk heading, or proliferation of bay grasses. The number of samples has been constant (n=75) since 1994, and sample sites were standardized in 1997. Samples collected in July were used to generate an index of bluefish abundance (Table 13).

4.4.12 VIMS Juvenile Bluefish Seine Survey

Virginia Institute of Marine Science (VIMS) developed a program to survey the abundance of juvenile bluefish in the waters along the bay and ocean sides of Virginia's Eastern Shore. Data are collected in waters with depths up to 1.5 m. The survey was started as an extension of the striped bass beach seine survey and was granted funding in 1994. A seine is used to sample fixed stations from June to October. Data collected in September are used to calculate an index of bluefish abundance as the geometric mean number per haul (Table 13).

4.4.13 SEAMAP

The Southeast Area Monitoring and Assessment Program (SEAMAP) fishery-independent trawl survey has sampled the coastal zone of the South Atlantic Bight between Cape Hatteras, North Carolina and Cape Canaveral, Florida since 1989. The R/V Lady Lisa is used to conduct sampling. Trawls are towed for twenty minutes, excluding wire-out and haul-back time, exclusively during daylight hours (1-hour after sunrise to 1-hour before sunset). Stations are randomly selected from a pool of stations within each stratum. Beginning in 2001, the number of stations sampled in each stratum was determined by optimal allocation stations within fourteen shallow water strata in both summer and the fall. A total of 52 stations were sampled from 1990 to 2000 and increased to 57 after 2000. Sampling stations are delineated by the 4 m depth contour inshore and the 10 m depth contour offshore. In 2001, sampling stations in deeper strata were eliminated in order to intensify sampling in the shallower depth zone. Sampling occurs in spring (early April - mid-May), summer (mid-July - early August), and fall (October - mid-November). SEAMAP collects biological information for 27 priority species and the contents of each net are sorted separately to species. In every collection, each of the priority species is weighed collectively and individuals are measured to the nearest centimeter. Sub-sampling is used when catch of a priority species is too large to measure every individual.

Indices determined in this study were based on young-of-the-year bluefish (<25 cm FL) collected from inshore strata during April. Also, samples from south of 30°N were eliminated from analyses due to low and sporadic catches of bluefish in the southern range of the survey. Although older bluefish are occasionally collected, age-0 fish greatly predominate. The indices suggest above average age 0 abundance in 1991,1992 and 1995 (Table 13; Table 14)

4.5 General Survey Results

The seasonality of bluefish spawning results in two annual cohorts often referred to as the spring cohort and summer cohort (Chiarella and Conover 1990). Young-of-the-year survey indices were partitioned into cohort based on size (summer cohort = 1-13 cm, spring cohort = 14-25 cm) (Table 16).

The fishery-independent surveys sample components of the bluefish stock with distinct seasonal migration patterns that vary by fish age. State and federal fisheries-independent survey data were normalized to compare trends among young-of-the-year indices (Figure 8). Correlations among cohorts and programs were examined, resulting in 210 comparisons (Table 17). Among the comparisons, 17 of 210 possible combinations had R-values exceeding 0.5. However, 50% (105 of 210) were negatively correlated with another index (Table 17).

Because the state indices measure temporal and spatial components of a migratory stock, the size and contributions of these components to the total stock cannot be quantified.

4.6 Data Discussion

The Bluefish Technical Committee evaluated the quality of the commercial, recreational, and age data for use in an analytical model. The highest amount of commercial sampling since 1997 occurred in the North Carolina and Virginia region, which also accounted for the highest proportion of landings. The committee felt the sampling amounts by gear and market grade were adequate to represent the length distribution of Atlantic coast bluefish landings. The amount of commercial sampling in the mid-1990s was poor (see SAW-23 report), however, it was believed that here was enough information covering the entire time series to capture the trends in size for landings since 1982.

The length sampling of recreational landings has remained relatively stable at about 3,000 to 4,000 fish per year from 1997 to 2004 (Table 7). Since bluefish landings are not rare events, intercepts likely provide representative information to characterize length distributions. The MRFSS provides a survey estimate with proportional standard error estimates. The average PSE values since 1994 for bluefish (4.2) was comparable to other species such as summer flounder (3.9) and striped bass (5.3). The Committee concluded that the recreational landings information was adequate for use in a bluefish assessment. Recreational discard estimates were also considered adequate although there remains a lack of discard length information.

Age information, although relatively sparse in some years, was determined to be adequate to characterize bluefish catch and indices. Bluefish growth is dominated by the increase in size at age-0 and age-1. The fast growth results in very strong signals within the length distributions with little overlap between cohorts. The committee accepted the recommendation of researchers that ages beyond age-6 based on scales may underestimate the true age. The committee concluded that although there may be some error introduced into analytical models due to combining age data across years it was not likely a fatal flaw in this instance.

Most state agencies between Massachusetts and Florida conduct some type of annual survey of marine finfish. Examination of the survey results did not reveal any consistent signal of bluefish abundance or biomass indices among programs. There appears to be several issues that create problems with bluefish survey data. First, the type of gear used in available survey programs (trawls or beach seines) is generally inefficient for catching bluefish, particularly once the fish reach a larger size and can easily evade the gear. The second problem is the wide-distribution of the bluefish stock along the Atlantic coast. Finally, there appears to be a partitioning of fish by size, with smaller fish most common inshore and larger fish most common in deeper offshore areas. Consequently, state coastal surveys tend to miss larger fish that are beyond the survey area. In addition, during the fall survey period individual state programs only sample a limited part of the population. The NEFSC inshore survey reduces some of the problem associated with temporal coverage, although there remains the issue of catchability of larger fish.

The relationship among age-0 bluefish indices from different programs may be further confounded by the strength of the juvenile cohort (spring vs. summer) that is being sampled. The correlations suggest that summer cohorts may produce similar signals among the northeastern states surveys, but with little correlation among spring cohorts. The mix of the spring and summer cohorts within an age-0 index may produce indices without a clear signal of abundance trends.

The Technical Committee concluded that although there was inherent uncertainty in the data, the data was adequate for use in an analytical model. The greatest area of uncertainty was in the accuracy of survey indices in following population trends. The committee felt that the recreational CPUE, although a fishery-dependent index, provided the greatest spatial coverage and had the least problem with catchability of larger fish. The approach was to evaluate the utility of each survey index based on their performance within a model framework.

5.0 TERM OF REFERENCE #2: Evaluate adequacy and appropriateness of models used to assess the species and to estimate population benchmarks.

After reviewing several model types such as the modified Delury model, a surplus production model, a VPA and catch-at-age models, the Committee concluded that age-based models such as a catch-at-age model or VPA model were most appropriate for a bluefish assessment (see appendix I for details on rejected models). The bluefish data were truncated to an age-6+ category to reduce the influence of ageing error. In addition, the catch-at-age distribution in past assessments has been identified as having a bimodal distribution, which was reduced with inclusion of more ages into a plus group.

The NFT ADAPT version of VPA was used as an initial model. The model is configured such that a partial recruitment vector is input for use in estimation of terminal year + 1 *F* and N. However, estimation of the oldest true age in the matrix in prior years does not account for a dome (or bimodal) shaped partial recruitment (PR) vector. An *F*-ratio other than 1 for calculation of the plus group *F* can help adjust for non-flat topped PR in the plus group. The ADAPT model was setup to use averaging within years rather than across years to avoid some issues associated with any bimodal PR.

The Committee concluded that although the VPA produced satisfactory results, the assumption of no error in the catch-at-age matrix and the way ADAPT handles selectivity may produce misleading results. Therefore, a catch-at-age model, ASAP from the NFT models, was chosen as the primary assessment tool. The ability of the ASAP model to allow error in the catch-at-age as well as the assumption of separability into year and age components makes it better suited to handle the selectivity patterns and catch data from the bluefish fishery. However, there is no diagnostic metric that allows direct comparison between ADAPT and ASAP models.

6.0 TERM OF REFERENCE #3: Evaluate and either update or re-estimate biological reference points as appropriate.

The biological reference points in the FMP were based on a surplus production model that was rejected during the SAW 39 review. Therefore there are no currently accepted reference points for Atlantic coast bluefish.

New biological reference points were developed for comparison to current stock status. The preferred ASAP model output estimated F_{MSY}=0.19 (Table 18). The model also estimated F_{MAX} = 0.28, $F_{0.1}$ = 0.18 and $F_{30\%}$ as 0.28 (Table 18). Alternative reference points were calculated with an age based Thompson-Bell yield-per-recruit model (Figure 9). Partial recruitment values were based on the average 1982-2003 ASAP selectivity estimates. The model was extended to age-7+ with a selectivity of 1.0. F_{MAX} was estimated at 0.25, $F_{0.1}$ = 0.17 and $F_{30\%}$ as 0.26 (Table 18). The current F of 0.146 is below F_{MSY} as well as alternative reference points. Therefore, it is concluded that bluefish is not experiencing overfishing.

Recruitment and spawning stock biomass are both estimated in the ASAP model and these values used to fit a Beverton-Holt S/R relationship. The parameters for bluefish were alpha = 35426.6 and beta = 41159.4 with a steepness of 0.7399 (Figure 10). In addition, SSB at msy was estimated equal to 142.1 million lbs. Using the SSB/R and B/R estimates from the Thompson-Bell model, we used the Shepherd/Sissenwine approach to calculate B_{msy} as 147.05 million pounds (Table 18). The current FMP defines overfished status as biomass below ½ B_{msy} which would be equal to 73.52 million pounds (Table 18). Therefore, with the current estimate of biomass equal to 104.1 million pounds, bluefish would not be considered overfished.

7.0 TERM OF REFERENCE #4: Estimate and evaluate stock status (biomass) and fishery status (fishing mortality rate). Is the stock overfished; is overfishing occurring?

7.1 ADAPT model

The initial bluefish model was the ADAPT VPA using a catch-at-age matrix from 1982 to 2004 through age-6+. The SAW-17 review of a bluefish assessment suggested that values of M should range from 0.2-0.25 instead of M=0.35 (NEFSC 1994a). Since the oldest aged bluefish is 14, an M of 0.2 was appropriate, using M=3/oldest age. The initial input PR was bimodal with a maximum value at age-1 of 1.0 and age-5 value of 0.74. The F ratio was set at 1.4 to create a higher F in the age-6+ group, forcing the model towards a bimodal F pattern. Full F was calculated as an average of F from age-2 to age-4 (since age-5 F was based on oldest true age estimation and age-6+ was function of the oldest true age).

Maturity at age was held constant over time as 0 at age-0, 0.25 at age-1, 0.75 at age-2 and 1.0 thereafter. Following initial runs including all available indices, the tuning indices were truncated based on proportional variance contributions to the overall model variance. The final tuning indices were limited to those with adults present (NEFSC inshore (age-0 – age-6+), CT trawl indices (age-0 – age-6+), NJ trawl indices (age-0 – age-2), DE adult trawl indices (age-0 – age-2), Rec CPUE (age-0 – age-6+), and the SEAMAP series to include an age-0 recruitment series from the South Atlantic Bight. Tuning was made to mid-year population size.

Results of the ADAPT indicate a reasonable fit to the model with a CV around the population estimates of 0.43 (age-0), 0.38 (age-1), 0.27 (age-3 and age-4) and 0.28 (age-5). The model fit to the indices tended to miss the abrupt peaks in the time series. The residual patterns for Rec CPUE age-1 and age-2 had a trend over time. However, when indices were removed from the model they had little influence on the results (the population CVs increased to 0.30 for age-3 – age-5). The fishing mortality rate in 2004 was estimated to be F_{2004}=0.12, a decline from 0.23 in 2001 (Table 19). Population size estimates increased steadily from 52,940 in 1998 to 97,216 in 2004 (using a geometric mean recruitment estimate since 2000) (Table 20) and biomass estimates increased from 47.9 million lbs in 2000 to 90.4 million lbs in 2004 (Table 21). Bootstrapped abundance estimates produced an 80% confidence interval of 78,793 to 108,963 thousand fish and a January 1 biomass distribution of 86.0 million to 140.9 million pounds (Figure 11). Similar bounds in *F* estimates ranged from 0.10 to 0.16 (Figure 11). The model configuration had no retrospective pattern in the *F* or population estimates (Figure 12)

7.2 Age-Structured Assessment Program (ASAP)

The input values from ADAPT were used as initial values for the ASAP model. ASAP allows selectivity and catchability patterns to vary over time. The model was structured to allow greater deviations from the indices than from the catch-at-age data. A selectivity pattern was fitted to the data and held constant for the periods 1982-1990,1991-1998 and 1999-2004. Recruitment was allowed to deviate from the fitted model after the 4th year.

The final model configuration resulted in a residual sum of squares of 0.0035 and a likelihood value of 7.058 (Table 22). When the model is allowed to vary selectivity to fit catch data, the resulting selectivity pattern was similar to the backcalculated PR in the ADAPT results and did not vary over time. The model closely predicted catch at age for the combined time series and annual catch when compared to the observed catch (Figure 13). Annual catch at age predictions were less accurate, particularly in years with unusually high or low age-0 and age-1 catch (Figure 14).

Predicted indices vary from observed estimates, in part because of the weighting schemes used in the model. Predicted indices are generally smoothed over time relative to observed values (Figure 15). Negative log-likelihood values were minimized for recreational CPUE at age, CT age-0 and DE age-1 (Figure 16). Similar to ADAPT, the early part of the REC age 1 time series was under-estimated. Overall the residual patterns scattered distributions with the exception of time trends in age 1 and age 2 recreational CPUE indices (Figure 17)

Fishing mortality estimates in ASAP are based on a separability assumption. F_{MULT} is the estimate of full F. The 2004 F_{MULT} value equals 0.149 (Table 23) . The trend in *F* has steadily declined since 1991 when *F* reached 0.41 (Figure 18). The time series of *F* from the VPA shows less variability since 1990, bounded between 0.1 and 0.23. If the average VPA F for ages 1-4 is compared to ASAP average F for the same ages, the resulting *F* trends between the two models are very similar.

January 1st population sizes show a general increase in overall abundance since 1997 (Table 24; Figure 19). Abundance estimates peaked in 1982 at 176 million fish, declined to 57 million in the mid-1990s and has since increased to 92 million fish (Table 19). Biomass estimates peaked in 1982 at 220.0 million lbs, then declined to 65 million lbs by 1997 before increasing to the 2004 level of 104 million lbs (Table 25; Figure 20). The magnitude of population estimates are similar to those produced in the VPA.

8.0 CONCLUSIONS

The Bluefish Technical Committee concluded that the results of the ASAP model were the best representation of the Atlantic coast bluefish population. There was some trade-off in the goodness of fit between the catch-at-age and survey indices in the model, but the overall model results were considered acceptable. The results also corresponded well to ADAPT model results. Although the agreement between models did not validate either model, it indicates that there was some signal in the data that could produce consistent output in two models with different assumptions. The model results lead to the conclusion that the Atlantic stock of bluefish is not experiencing overfishing nor is it overfished.

9.0 RESEARCH RECOMMENDATIONS FROM SAW 39 PANEL

Data

Release Mortality

- The mortality of bluefish released by anglers is a key parameter because of the large proportion now released alive, and should be the subject of a more detailed investigation. This should include effect of any potentially significant factors such as fish size, sex, method of capture, and season.
    - No new studies have been conducted since SAW 39.

Recreational Catch Rate

- Recreational catch rate is important, so the data should be collected in a manner that allows analysis of changes in angler behavior, composition, technology, or other factors that influence both the statistical distribution of individual catch rate and changes in catchability over time.
    - Data collection made under the MRFSS program with a standard sampling protocol. That protocol has not been changed.

- Terceiro (2003) has done much of the groundwork needed to develop a recreational catch rate abundance index. Poisson quasi-likelihood may be the simplest error model to apply. If possible, all trips should be used, and targeting should be allowed for as factor in the GLM.

  - The Terceiro method was used in calculation of recreational catch rates for the current analysis.

Catchability

- An assumption of constant catchability in recreational catch rates is likely to give an optimistic view of the state of the stock unless there has been a significant increase in less efficient anglers over time, and must remain an issue of concern that needs to be addressed externally to the model, through a more comprehensive analysis of recreational catch data.
  - The change in angler efficiency is partially addressed through use of the GLM model. However, a lack of angler specific information prohibits detailed analysis of changes in catchability.

Indices

- Catch rate and survey indices should both continue to be used for assessment purposes, if possible. However, models other than a catch rate index should at least be considered.
  - Recreational catch rates and survey indices were used in the current assessment, which is a forward-projecting age-structured model.

- There is a need for an integrated analysis of the many different research surveys for juvenile bluefish. The surveys cover different regions using different gear types and provide data on 0- and 1-group bluefish. It is recommended that serious consideration be given to convening a workshop to evaluate: 1) the quality of the individual data sets; 2) the potential ability of the surveys to index bluefish abundance at age in the areas surveyed; 3) coherence of trends in localized surveys with trends in nearby stations of the larger scale surveys; and 4) methods for standardizing and combining data from small-scale intensive surveys with large-scale less spatially intensive surveys, to give improved indices of recruitment. Such a workshop would require consolidation of raw survey data from the different surveys into common databases.
  - An attempt was made to consolidate state survey data into a single comprehensive index. Available data limited progress on the analysis at this time. It has been suggested to the ASMFC that a workshop to conduct this consider this approach is warranted.

Age Data

- Age composition data should be collected to allow continued development of fully age-structured assessment models, particularly in light of the unusual selectivity patterns estimated from earlier catch-at-age analyses.
  - Data collection continues but limited efforts have been made towards generating coast wide age information.

Maturity

- Maturity ogives need to be constructed and presented in future assessments.
  - This has not been done to date.

Tagging Studies

- The feasibility of using tagging studies to estimate mortality, selectivity and movements, as well as to determine tag retention, should be investigated.
    - A manuscript regarding a tagging study of bluefish along the Atlantic coast is currently in review.

Catch Data

- Catches should not be presumed to be exact, but can be fitted through some likelihood function for discrepancies between observed and estimated catch in the population model. The likelihood can use the standard error of the catch estimate.
    - This has been addressed through the use of the ASAP model.

Use of GLM

- Care should be taken when using a GLM index approach that information relevant to changes in stock size is not mistakenly removed. A better approach might be to integrate the GLM into a population model.
    - Only the recreational CPUE was subjected to a GLM analysis in this assessment. Fisheries independent indices were modeled by the assessment model.
    -

International Work

- Stock assessment methods applied to bluefish elsewhere in the world should be evaluated for applicability to the NE US situation.
    - An extensive search of international work found a recent assessment of bluefish conducted in Queensland, Australia had potential applicability to the US East Coast situation. Leigh and O'Neill (2004) applied three different stock assessment models to data collected from the Australian east coast tailor fishery to evaluate stock status. Results of a surplus production model were considered unreliable. The main concerns with the outcome of the various model scenarios were parameter estimates that were unrealistic for tailor, the surplus production method's inability to model partial selectivity of mature fish, and convergence on local minima. An age-structured model and a fully integrated age-length model were also evaluated. The age-length model structured the population by both length and age. The development of the age-length model was prompted by a desire to capture the observed changes in length-at-age of tailor over the years. Unlike the strictly age-structured model, this model is able to directly fit observed length frequencies rather than first converting them to ages. Ageing data are applied only in years when age data are available, instead of extrapolating to years with missing age data.
    - The current data available for the US east coast bluefish stock could support development of an age-length model. Commercial and recreational fishery length samples are available back to 1982 and at least seven fishery-independent surveys have collected 20 or more years of length data on bluefish. North Carolina has 13 years of age data based on scales and 5 years of otolith-based ages. Virginia has been processing otolith ages since 1998. Application of a fully integrated model could incorporate all these data and avoid some of the disadvantages of age-structured analyses. It would not be necessary to combine age-length keys

across years, or even gear type depending on the model configuration. Other advantages include ability to model selectivity patterns as a function of size, incorporation of variation in size-at-age, and ability to include an explicit growth function.
   - Leigh, G.M. and M.F. O'Neill. 2004. Stock assessment of the Queensland-New South Wales Tailor Fishery (*Pomatomus saltatrix*). Queensland Department of Primary Industries and Fisheries QI04065.

Intermediate Models

- Pending ability to apply full age-structured methods, the use of partially age-structured methods such as the Collie-Sissenwine model is recommended to allow explicit incorporation of survey estimates for 0- and 1-group fish, so estimating the contribution of recruitment to annual production. This would require that the commercial fishery and recreational catches and cpue be disaggregated into recruits and older fish. The effect of poor data on discards of young bluefish in the commercial fishery on such an analysis requires evaluation.
   - A Collie-Sissenwine model was attempted in this assessment (see appendix). However, it was not successful for various reasons. A modification of the model structure in future work may eliminate the issues identified.

Model Optimization

- Global search algorithms (e.g. genetic algorithms) should be used for parameters if an ASPIC model is used in future.
   - ASPIC was not the model of choice in this assessment. Recent changes have been made to the search algorithm in the NFT ASPIC software.

Management

- As the current assessment has been rejected, and the status of the stock is unknown, the total allowable landings specification should continue at current value.
   - Management has been status quo since the assessment was rejected.

- Reducing fishing mortality to allow the abundance indices to increase could provide useful information on the productivity of the stock. A much-improved assessment may be obtained when a recovery has taken place.
   - No action taken.

10.0 TERM OF REFERENCE #5: Research Recommendations

Commercial Data

- Increase sampling of size and age composition by gear type and statistical area
- Target landings for biological data collection and increase intensity of sampling for biological data.

Recreational Data

- Increase sampling of size and age composition by gear type and statistical area
- Target landings for biological data collection and increase intensity of sampling for biological data.

Ageing Data

- Complete a scale-otolith comparison study
- Conduct study or workshop to address discrepancies between estimated bluefish age from scales and otoliths and the chronological age. Examine issues of inter- and intra-reader variation in interpretation of ages
- Examine the feasibility of each state collecting samples of hard parts for ageing, with one or two laboratories interpreting the annuli for consistency.

Fishery-Independent Data

- Continue research on species interactions and predator-prey relationships
- Examine alternative weighting schemes for the available fishery-independent surveys (*e.g.* area, inverse variance, N, etc.)
- Investigate the feasibility of alternative survey methods that target bluefish across all age classes to create a more representative fishery-independent index of abundance
- Initiate sampling of offshore populations in winter months
- Conduct research on influences on recruitment including pathways of larval bluefish
- Initiate coastal surf zone seine study to provide more complete indices of juvenile abundance.

Models, Inputs, and Outputs

- Explore a tag based assessment and associated costs compared to age based assessments
- Determine if a tag based assessment could supplement or replace other assessment techniques
- Continue to examine alternative models including a forward projection catch-at-age model.

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Table 1. Summary of Atlantic coast bluefish commercial and recreational catch.

Year	Commercial Landings (mt)	Commercial Landings (000 lbs)	Commercial Landings (000s)	Recreational Landings (000s)	Recreational Discards (000s)	Recreational Discards (000s)	Recreational Catch (000s)	Recreational Landings (mt)	Recreational Discards (mt)	Recreational Catch (mt)	Total Catch (000s)	Total Catch (mt)
1974	4,538	10,005				(assumes 15%						
1975	4,402	9,705				release mortality)			assumes same			
1976	4,546	10,022							mean wt			
1977	4,802	10,587							as landings			
1978	4,986	10,992										
1979	5,693	12,551										
1980	6,857	15,117										
1981	7,465	16,457										
1982	6,997	15,426	7,699	23,724	3,497	525	24,248	37900	838	38,738	31,947	45,735
1983	7,166	15,798	5,556	24,884	5,254	788	25,672	41159	1,304	42,463	31,228	49,629
1984	5,380	11,861	5,849	20,798	5,710	857	21,654	31089	1,280	32,369	27,503	37,749
1985	6,122	13,497	4,340	19,246	3,228	484	19,730	24035	605	24,640	24,070	30,762
1986	6,651	14,663	6,658	24,441	5,970	895	25,336	43607	1,598	45,205	31,994	51,856
1987	6,578	14,502	4,467	21,076	6,527	979	22,055	36255	1,684	37,939	26,522	44,517
1988	7,161	15,787	3,805	9,905	3,460	519	10,424	22773	1,193	23,966	14,229	31,127
1989	4,740	10,450	2,978	13,600	5,037	756	14,356	18772	1,043	19,815	17,334	24,555
1990	6,250	13,779	3,605	11,365	5,081	762	12,127	14750	989	15,739	15,732	21,989
1991	6,160	13,580	7,747	11,943	6,349	952	12,895	16153	1,288	17,441	20,642	23,601
1992	5,205	11,475	10,063	7,158	4,242	636	7,794	12031	1,070	13,101	17,857	18,306
1993	4,808	10,600	1,969	5,725	4,200	630	6,355	9979	1,098	11,077	8,324	15,885
1994	4,304	9,489	2,325	5,768	6,152	923	6,691	7884	1,261	9,145	9,016	13,449
1995	3,628	7,998	2,068	5,168	5,326	799	5,967	7303	1,129	8,432	8,035	12,060
1996	4,113	9,068	1,842	4,205	5,316	797	5,002	6276	1,190	7,466	6,844	11,579
1997	4,064	8,960	2,955	5,413	7,161	1,074	6,487	7730	1,534	9,264	9,443	13,328
1998	3,741	8,246	3,161	4,202	5,002	750	4,952	6585	1,176	7,761	8,113	11,501
1999	3,334	7,351	2,411	3,682	7,806	1,171	4,853	5379	1,711	7,090	7,264	10,424
2000	3,659	8,066	2,662	4,897	11,363	1,705	6,602	6196	2,157	8,353	9,264	12,011
2001	3,945	8,698	2,823	6,663	13,749	2,062	8,726	7533	2,332	9,865	11,549	13,810
2002	3,119	6,876	2,142	5,300	9,917	1,488	6,788	6596	1,851	8,447	8,930	11,566
2003	3,359	7,406	2,161	6,045	8,996	1,349	7,395	7967	1,778	9,745	9,555	13,105
2004	3,783	7,200	1,847	6,939	11,739	1,761	8,700	6870	1,743	8,613	10,547	12,396

Table 2. Bluefish Atlantic coast commercial landings (mt) by state.

Year	ME	NH	MA	RI	CT	NY	NJ	DE	MD	VA	NC	SC	GA	FL	mt
1950			27.8	25.4	9.5	57.7	587.7	9.4	47.8	141.4	576.9	4.7		448.9	1,937.2
1951			12.9	16.7	24.8	86.7	499.1	2.2	38.4	81.3	420.0	5.3		649.2	1,836.6
1952			0.4	21.9	40.8	94.3	653.0	0.4	50.4	65.2	334.2	5.0		505.8	1,771.4
1953			13.6	36.4	25.2	73.7	409.4	1.1	20.9	79.4	245.7	3.2		500.6	1,409.2
1954			14.0	41.6	11.0	182.1	572.0	1.0	40.4	83.8	146.6	3.6		364.9	1,461.0
1955			16.8	14.2	14.3	212.7	460.3	1.2	28.7	99.7	197.3	17.7		459.4	1,522.3
1956			8.7	21.2	5.9	168.2	502.9	1.5	46.0	101.6	287.1	24.2		349.7	1,517.0
1957			11.2	26.9	8.6	189.7	415.7	1.9	42.0	87.5	370.1	32.4		502.2	1,688.2
1958			1.4	4.5	1.0	52.3	41.2	2.8	14.7	70.6	198.2	1.1		383.3	771.1
1959			2.4	8.9	2.6	118.7	170.4	2.0	13.5	82.8	335.8	0.6		582.2	1,319.9
1960			6.9	15.5	2.5	187.9	200.9	0.2	4.7	59.1	278.7	0.1		494.5	1,251.0
1961			8.1	22.2	4.9	229.2	209.3		8.6	133.2	341.3	0.4	0.2	444.2	1,401.6
1962			15.5	49.6	14.3	344.0	495.1	3.7	28.9	237.8	433.0	2.1		631.8	2,255.8
1963			21.5	37.2	23.5	316.0	373.3	9.7	18.9	286.9	368.5	51.7		618.1	2,125.3
1964			18.9	41.0	27.4	306.2	245.5		2.9	179.2	233.5	143.5		545.1	1,743.2
1965			64.7	49.0	27.0	470.0	394.7	0.1	3.2	93.2	319.2	38.3		387.7	1,847.1
1966			57.5	32.6	25.2	423.2	457.3	0.4	7.7	109.5	372.1	71.8	0.2	614.0	2,171.5
1967			31.9	36.1	28.2	249.5	227.8	0.1	7.9	54.5	402.7	21.6		610.8	1,671.1
1968			39.5	36.9	28.2	261.3	346.9	0.2	63.9	109.4	395.7	10.8		866.7	2,159.5
1969			68.2	56.1	37.8	507.8	308.6		24.4	101.2	395.1	2.4		943.6	2,445.2
1970			76.7	146.3	38.4	726.5	482.4		31.4	292.7	224.9	3.8		928.1	2,951.2
1971		0.7	124.2	122.9	37.5	549.2	444.1		64.1	277.0	262.1	5.9		737.2	2,624.9
1972			168.9	141.9	22.4	455.0	368.1	0.3	26.5	551.6	529.6			850.8	3,115.1
1973	26.8		252.1	126.0	43.7	640.2	402.6	1.2	124.8	1,317.8	910.9	1.4		718.0	4,565.5
1974	13.4		177.0	121.0	40.3	484.0	455.0	2.7	253.6	1,423.1	990.4	0.1		577.3	4,537.9
1975	5.2		249.3	173.0	6.7	403.3	581.1	6.8	125.5	1,490.2	896.0	1.0	0.2	463.2	4,401.5
1976	0.2		204.1	109.7	10.5	272.1	580.6	5.3	232.7	1,890.1	614.9	0.4		625.8	4,546.4
1977	0.1	0.1	228.5	111.0	5.6	447.1	634.1	14.6	237.6	1,437.5	1,057.5	4.6	0.3	622.9	4,801.5
1978	14.7	1.1	361.9	169.6	24.8	792.1	718.9	18.3	147.2	1,243.1	883.6	4.4	0.1	605.8	4,985.6
1979	30.5	0.2	257.0	146.6	23.1	731.0	720.8	22.9	144.7	1,389.9	1,544.8	5.9	0.1	675.4	5,692.9
1980	43.6	0.6	314.5	165.6	22.4	674.9	635.3	74.4	198.1	1,277.8	2,469.2	1.5		978.9	6,856.8
1981	41.0	20.5	372.1	160.4	141.5	580.7	832.1	88.9	188.5	1,061.6	2,997.0	1.3	0.5	978.7	7,464.8
1982	74.8	30.3	406.1	270.5	136.1	781.4	898.5	231.8	131.1	1,176.2	1,945.9	2.8	0.3	910.8	6,996.6
1983	77.1	13.9	453.6	235.6	31.5	765.3	873.0	131.7	149.8	689.4	3,060.5	5.1	0.1	679.8	7,166.4
1984	22.0	8.0	318.3	462.3	45.3	742.1	767.3	71.3	83.9	525.2	1,614.5	0.6		719.1	5,379.9
1985	41.0	10.3	362.2	767.8	82.4	967.6	902.0	85.3	231.0	749.8	1,633.9	0.2		288.5	6,122.0
1986	46.9	27.7	708.6	518.4	86.2	733.6	1,362.3	181.5	207.0	686.4	1,561.9	1.3	0.8	528.6	6,651.2
1987	47.9	58.0	361.6	537.4	79.7	709.7	1,148.4	160.8	164.9	536.3	2,068.8	1.5	1.2	702.2	6,578.4
1988	4.0	10.4	365.7	464.4	46.3	510.4	1,126.5	94.9	467.8	1,186.4	2,285.6	1.6	0.3	597.1	7,161.4
1989	34.4	62.2	562.3	549.7	88.0	256.2	717.8	47.3	125.1	349.5	1,492.8	1.2		453.4	4,739.9
1990	24.5	89.4	546.1	537.4	81.2	731.2	984.8	65.3	129.4	495.0	2,075.9	0.5		488.9	6,249.6
1991	56.7	57.7	343.0	676.1	116.8	716.0	1,110.2	153.1	105.8	373.5	1,777.9	0.6		672.5	6,159.9
1992	39.2	103.5	376.3	703.1	121.9	677.1	997.0	42.0	93.6	269.1	1,287.8	0.3	0.1	494.2	5,205.2
1993	8.3	73.7	288.5	542.0	61.0	702.6	994.0	13.4	60.5	294.7	1,226.4	0.1		543.1	4,808.3
1994	24.5	124.8	543.2	409.0	68.9	667.6	858.2	15.6	74.7	284.7	808.5	0.8		423.4	4,303.9
1995	8.8	84.8	252.9	350.2	53.2	590.3	384.5	16.6	48.8	243.7	1,365.4			228.6	3,627.8
1996	5.5	72.5	409.2	291.1	45.9	719.8	731.0			279.4	1,496.3	0.9		60.9	4,112.5
1997	1.2	28.3	197.0	270.6	32.7	682.5	559.3	13.3		335.5	1,815.3			128.6	4,064.3
1998		7.5	164.9	258.8	25.5	716.0	627.4	12.5	84.1	360.5	1,326.8			154.5	3,738.5
1999	-	5.5	186.4	272.3	24.1	644.7	490.0	8.9	65.9	223.1	1,252.4		0.2	156.3	3,329.8
2000	0.1	10.9	128.1	157.6	15.2	843.9	608.5	13.2	38.2	241.7	1,525.3			64.2	3,646.9
2001		5.3	158.1	219.3	20.8	624.3	583.6	8.5	59.2	358.8	1,844.3	0.2		62.7	3,945.1
2002	0.4	2.4	184.5	254.6	24.6	669.1	601.0	20.8	51.5	215.6	1,054.2			37.1	3,115.8
2003	0.3	3.9	150.2	189.6	20.3	707.6	459.2	13.9	24.0	171.5	1,574.0	0.1		44.8	3,359.4
2004															

Table 3. Bluefish Atlantic coast recreational landings and discards in numbers (000s), by state.

Landings

	ME	NH	MA	RI	CT	NY	NJ	DE	MD	VA	NC	SC	GA	FL (east)	
1982	9	1	667	2,869	5,451	3,128	2,936	235	2,166	1,078	2,927	476	37	1,744	23,724
1983	39	5	1,451	3,741	1,208	5,426	3,953	341	2,124	577	4,311	148	100	1,459	24,884
1984	0	6	795	746	3,272	5,822	2,941	203	1,737	455	2,197	279	180	2,166	20,798
1985	46	-	431	1,478	3,135	3,760	2,683	120	3,642	650	1,754	431	20	1,096	19,246
1986	149	66	2,244	1,874	2,515	6,914	4,808	161	2,064	850	1,679	157	19	940	24,441
1987	289	74	1,420	825	2,535	5,386	4,727	100	2,241	565	1,738	164	44	967	21,076
1988	63	32	693	440	664	1,454	1,754	255	1,229	437	1,822	87	8	968	9,905
1989	38	23	412	487	1,468	3,984	2,889	324	711	707	1,605	226	16	711	13,600
1990	47	27	416	447	1,034	2,738	2,177	242	707	743	2,229	76	43	439	11,365
1991	115	41	840	441	1,729	3,471	2,012	147	953	666	821	39	24	643	11,943
1992	95	24	345	250	1,185	1,196	1,908	189	367	163	682	33	8	715	7,158
1993	29	28	511	188	825	1,440	656	138	217	66	723	81	5	818	5,725
1994	66	18	434	297	512	1,605	941	120	473	231	452	118	4	497	5,768
1995	9	12	405	126	608	1,042	1,243	183	285	213	387	154	15	487	5,168
1996	10	3	285	361	624	545	957	136	346	324	299	55	4	256	4,205
1997	13	25	316	412	519	816	942	159	433	447	742	89	5	494	5,413
1998	2	3	237	194	387	768	817	150	284	223	527	171	22	418	4,202
1999	8	4	197	330	440	710	809	84	167	134	518	34	12	235	3,682
2000	-	1	221	280	390	718	1,236	132	344	150	878	88	20	439	4,897
2001	15	8	357	365	716	1,005	1,431	102	429	261	1,266	118	10	581	6,663
2002	24	19	229	325	569	751	1,321	117	199	131	777	79	2	759	5,300
2003	14	8	374	334	458	1,147	1,571	89	214	172	953	66	1	644	6,045
2004	18	22	426	273	552	1,442	1,818	133	318	256	1,057	119	1	504	6,939

Discards

	ME	NH	MA	RI	CT	NY	NJ	DE	MD	VA	NC	SC	GA	FL (east)	
1982	3	-	59	152	886	197	346	47	690	452	301	107	53	204	3,497
1983	2	1	636	42	64	1,743	784	36	711	170	765	17	67	214	5,254
1984	-	-	354	55	257	2,570	709	89	512	138	242	77	37	671	5,710
1985	8	1	160	123	327	955	537	34	257	118	333	182	38	155	3,228
1986	25	23	1,318	71	155	1,852	1,162	44	287	315	449	48	29	192	5,970
1987	191	8	639	268	291	1,879	1,697	64	478	181	545	47	33	206	6,527
1988	23	2	298	70	27	735	437	35	266	715	550	64	7	229	3,460
1989	5	17	266	86	131	1,474	1,084	191	446	294	750	145	22	127	5,037
1990	36	6	308	317	228	1,262	1,062	104	388	280	728	66	132	165	5,081
1991	327	24	579	195	552	1,367	1,545	59	369	451	551	17	66	246	6,349
1992	67	13	451	235	415	784	536	122	99	278	796	16	44	388	4,242
1993	18	22	390	153	261	975	561	105	194	163	784	56	22	495	4,200
1994	52	8	350	201	282	1,171	894	46	246	462	1,481	140	20	799	6,152
1995	5	7	585	70	171	719	637	127	273	417	1,201	221	85	808	5,326
1996	57	3	467	439	367	661	959	83	465	420	736	86	26	547	5,316
1997	83	3	644	320	293	898	849	193	891	662	1,149	197	20	956	7,161
1998	-	1	510	203	405	589	702	275	492	405	534	200	71	615	5,002
1999	20	5	397	784	744	1,156	1,824	323	605	228	986	59	14	661	7,806
2000	4	1	596	497	863	2,629	1,907	303	1,150	321	1,630	182	79	1,201	11,363
2001	40	14	948	893	1,429	2,543	2,056	221	1,074	625	2,329	152	48	1,376	13,749
2002	42	14	628	801	662	1,017	2,168	435	577	382	1,610	163	26	1,392	9,917
2003	23	17	1,019	932	542	1,305	1,913	120	518	340	1,416	215	23	622	9,004
2004	39	10	1,490	749	1,015	1,848	2,333	319	669	510	1,930	352	17	457	11,740

Table 4. Number of bluefish sampled from commercial fisheries, 1997-2004

Maine to Maryland

Year		Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	sum
1997	small			200	106	
	med	100	83	69	156	
	large		200	104	59	
	unclassified		59	37	77	1,250
1998	small			545		
	med		115		213	
	large		100	295		
	unclassified			202	36	1,506
1999	small		133	205		
	med			62		
	large		446	58		
	unclassified		741		106	1,751
2000	small			202		
	med	100				
	large	101	292	115		
	unclassified	14	207	144	53	1,228
2001	small			190		
	med		100		86	
	large			102	200	
	unclassified		183	325	71	1,257
2002	small	29		173	205	
	med		130	200		
	large		162			
	unclassified		82	199	29	1,209
2003	small					
	med		296		111	
	large		308	259	20	
	unclassified		235	201		1,430
2004	small			82	99	
	med				212	
	large		410	338	220	
	unclassified		796	1,310	1,031	4,498

Virginia

Year		Jan-Jun	Jul-Dec	sum
1997	small	39	214	
	med	851	1,562	
	large	39	45	
	unclassified	739	736	4,225
1998	small	644	444	
	med	543	674	
	large	80	141	
	unclassified	443	642	3,611
1999	small	225	263	
	med	523	741	
	large	469	513	
	unclassified	78	267	3,079
2000	small	228	487	
	med	1,609	1,775	
	large	107	107	
	unclassified	188	390	4,891
2001	small	621	340	
	med	483	401	
	large	304	304	
	unclassified	465	337	3,255
2002	small	638	599	
	med	585	1,854	
	large	571	511	
	unclassified	363	533	5,654
2003	small	238	535	
	med	704	798	
	large	517	636	
	unclassified	485	226	4,139
2004	small	874	728	
	med	318	366	
	large	100	106	
	unclassified	42	330	2,864

North Carolina

Year		Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	sum
1997	small		585	322	103	
	med	195	382	296	428	
	large	225	16	1	183	
	unclassified	163	543	337	134	3,913
1998	small	21	120	193	-	
	med	189	1,383	491	193	
	large	459	108	-	220	
	unclassified	142	121	215	138	3,993
1999	small	3	46	34	71	
	med	1,311	1,893	434	56	
	large	1,605	116	43	262	
	unclassified	14	351	88	61	6,388
2000	small	137	180	45	45	
	med	190	1,013	1,196	837	
	large	1,784	817		289	
	unclassified	419	547	253	339	8,091
2001	small	517	390	222	71	
	med	1,995	2,277	602	105	
	large	2,133	859	2	258	
	unclassified	64	1,038	401	150	11,084
2002	small	138	252	72	200	
	med	1,282	397	808	472	
	large	1,245	697	78	507	
	unclassified	798	423	397	174	7,940
2003	small	308	210	35	2	
	med	535	1,117	626	256	
	large	2,050	982		352	
	unclassified	74	706	296	112	7,661
2004	small	180	266	20	72	
	med	1,600	589	526	953	
	large	1,704	1,337	34	813	
	unclassified	135	542	500	221	9,492

NC Bait Fishery

	Jan-Jun	Jul-Dec	sum
1997	91	203	294
1998	298	189	487
1999	49	422	471
2000	64	132	196
2001	369	221	590
2002	36	272	308
2003	84	114	198
2004	40	74	114

Table 5. Commercial Landings (lbs) 1997-2004 by period and market category.

Maine to Maryland

Year	Category	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
1997	small	3,695	14,141	154,541	110,241
	med	11,518	118,090	277,440	219,531
	large	2,698	209,369	133,583	152,033
	unclassified	16,640	464,768	1,376,305	767,592
1998	small	3,079	57,835	281,823	142,208
	med	1,440	146,177	191,597	286,039
	large	713	149,937	199,127	195,526
	unclassified	7,035	517,516	1,152,656	849,453
1999	small	1,018	46,824	133,366	87,347
	med	2,993	143,095	115,502	167,659
	large	7,574	213,049	113,921	338,687
	unclassified	12,437	536,672	1,213,209	609,587
2000	small	2,507	19,981	181,189	115,596
	med	9,474	99,906	112,652	196,955
	large	8,403	323,479	454,581	265,733
	unclassified	3,379	601,200	1,114,944	492,573
2001	small	322	9,289	93,506	104,163
	med	2,476	274,137	159,410	139,296
	large	6,826	456,436	199,838	232,986
	unclassified	1,681	578,576	1,017,276	425,346
2002	small	6,747	24,477	217,447	177,921
	med	12,658	447,093	133,368	130,594
	large	25,784	452,286	116,171	163,468
	unclassified	19,756	547,697	1,035,984	476,146
2003	small	1,191	15,807	48,405	39,659
	med	6,349	200,954	185,263	267,065
	large	177	232,656	241,607	220,684
	unclassified	3,216	518,530	902,272	575,081
2004	small	8,580	16,895	88,661	52,718
	med	618	307,278	320,655	264,529
	large	4,666	394,904	433,748	283,542
	unclassified	126	258,965	671,507	553,357

Virginia

Year	Category	Jan-Jun	Jul-Dec
1997	small	1,928	11,916
	med	9,235	62,468
	large	4,493	44,091
	unclassified	68,434	447,676
1998	small	1,545	11,148
	med	34,911	55,139
	large	8,675	62,996
	unclassified	109,317	334,446
1999	small	3,068	7,932
	med	26,456	19,497
	large	4,761	7,932
	unclassified	65,618	247,130
2000	small	3,869	5,493
	med	12,893	53,210
	large	14,182	9,162
	unclassified	59,171	322,492
2001	small	2,599	7,183
	med	35,435	48,310
	large	2,190	31,436
	unclassified	174,923	446,704
2002	small	135	5,800
	med	10,305	47,245
	large	5,320	2,906
	unclassified	69,092	289,733
2003	small	29	3,319
	med	29,428	24,866
	large	1,236	8,424
	unclassified	94,715	182,781
2004	small	80	4,187
	med	4,815	49,144
	large	4,987	60,210
	unclassified	32,955	254,445

North Carolina

Year	Category	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
1997	small	20,107	57,263	28,700	50,354
	med	178,225	286,149	160,727	276,594
	large	1,636,777	130,059	15,541	1,164,687
	unclassified	257	1,957	2,601	17,077
1998	small	16,083	55,566	9,003	34,478
	med	265,073	529,851	80,201	207,573
	large	1,266,661	155,667	7,366	251,657
	unclassified	32,002	17,689	3,007	2,925
1999	small	6,551	30,150	6,609	10,385
	med	539,873	323,615	55,077	24,994
	large	1,383,285	266,671	2,936	61,108
	unclassified	1,761	40,245	1,092	552
2000	small	6,647	32,420	19,420	16,800
	med	33,911	164,172	145,319	329,330
	large	1,876,457	603,066	6,059	103,046
	unclassified	493	7,526	2,761	12,168
2001	small	16,829	34,968	18,824	20,654
	med	694,722	340,709	100,452	47,896
	large	1,829,400	460,128	4,519	427,291
	unclassified	10,402	42,816	7,784	2,337
2002	small	9,657	20,067	10,774	19,228
	med	249,253	95,284	78,592	108,066
	large	1,103,802	141,567	24,547	426,096
	unclassified	1,623	16,436	6,591	4,326
2003	small	25,251	29,979	4,228	4,155
	med	448,955	388,941	106,044	78,913
	large	1,258,917	422,787	2,245	585,668
	unclassified	4,635	45,378	11,171	13,786
2004	small	4,466	20,881	10,771	10,830
	med	391,836	308,364	103,616	202,771
	large	1,477,056	418,753	11,567	723,008
	unclassified	31,016	8,897	4,117	17,874

NC Bait Fishery-(Estimated Landings)

	Jan-Jun	Jul-Dec
1997	10,966	36,006
1998	8,038	21,881
1999	51,720	22,348
2000	16,909	12,621
2001	47,337	10,827
2002	1,488	11,876
2003	8,316	14,279
2004	15,935	10,185

Table 6. Relative Commercial Sampling (fish measured per 100 lbs landed) 1997-2004

Maine to Maryland

Year		Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
1997	small	-	-	0.13	0.10
	med	0.87	0.07	0.02	0.07
	large	-	0.10	0.08	0.04
	unclassified	-	0.01	0.00	0.01
1998	small	-	-	0.19	-
	med	-	0.08	-	0.07
	large	-	0.07	0.15	-
	unclassified	-	-	0.02	0.00
1999	small	-	0.28	0.15	-
	med	-	-	0.05	-
	large	-	0.21	0.05	-
	unclassified	-	0.14	-	0.02
2000	small	-	-	0.11	-
	med	1.06	-	-	-
	large	1.20	0.09	0.03	-
	unclassified	0.41	0.03	0.01	0.01
2001	small	-	-	0.20	-
	med	-	0.04	-	0.06
	large	-	-	0.05	0.09
	unclassified	-	0.03	0.03	0.02
2002	small	0.43	-	0.08	0.12
	med	-	0.03	0.15	-
	large	-	0.04	-	-
	unclassified	-	0.01	0.02	0.01
2003	small	-	-	-	-
	med	-	0.15	-	0.04
	large	-	0.13	0.11	0.01
	unclassified	-	0.05	0.02	-
2004	small	-	-	0.09	0.19
	med	-	-	-	0.08
	large	-	0.10	0.08	0.08
	unclassified	-	0.31	0.20	0.19

Virginia

Year		Jan-Jun	Jul-Dec
1997	small	2.02	1.80
	med	9.21	2.50
	large	0.87	0.10
	unclassified	1.08	0.16
1998	small	41.68	3.98
	med	1.56	1.22
	large	0.92	0.22
	unclassified	0.41	0.19
1999	small	7.33	3.32
	med	1.98	3.80
	large	9.85	6.47
	unclassified	0.12	0.11
2000	small	5.89	8.87
	med	12.48	3.34
	large	0.75	1.17
	unclassified	0.32	0.12
2001	small	23.89	4.73
	med	1.36	0.83
	large	13.88	0.97
	unclassified	0.27	0.08
2002	small	472.59	10.33
	med	5.68	3.92
	large	10.73	17.58
	unclassified	0.53	0.18
2003	small	820.69	16.12
	med	2.39	3.21
	large	41.83	7.55
	unclassified	0.51	0.12
2004	small	1,092.08	17.39
	med	6.60	0.74
	large	2.01	0.18
	unclassified	0.13	0.13

North Carolina

Year		Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
1997	small	-	1.02	1.12	0.20
	med	0.11	0.13	0.18	0.15
	large	0.01	0.01	0.01	0.02
	unclassified	63.42	27.75	12.96	0.78
1998	small	0.13	0.22	2.14	-
	med	0.07	0.26	0.61	0.09
	large	0.04	0.07	-	0.09
	unclassified	0.44	0.68	7.15	4.72
1999	small	0.05	0.15	0.51	0.68
	med	0.24	0.58	0.79	0.22
	large	0.12	0.04	1.46	0.43
	unclassified	0.80	0.87	8.06	11.05
2000	small	2.06	0.56	0.23	0.27
	med	0.56	0.62	0.82	0.25
	large	0.10	0.14	-	0.28
	unclassified	84.99	7.27	9.16	2.79
2001	small	3.07	1.12	1.18	0.34
	med	0.29	0.67	0.60	0.22
	large	0.12	0.19	0.04	0.06
	unclassified	0.62	2.42	5.15	6.42
2002	small	1.43	1.26	0.67	1.04
	med	0.51	0.42	1.03	0.44
	large	0.11	0.49	0.32	0.12
	unclassified	49.17	2.57	6.02	4.02
2003	small	1.22	0.70	0.83	0.05
	med	0.12	0.29	0.59	0.32
	large	0.16	0.23	-	0.06
	unclassified	1.60	1.56	2.65	0.81
2004	small	4.03	1.27	0.19	0.66
	med	0.41	0.19	0.51	0.47
	large	0.12	0.32	0.29	0.11
	unclassified	0.44	6.09	12.14	1.24

NC Bait Fishery

	Jan-Jun	Jul-Dec
1997	0.83	0.56
1998	3.71	0.86
1999	0.09	1.89
2000	0.38	1.05
2001	0.78	2.04
2002	2.42	2.29
2003	1.01	0.80
2004	0.25	0.73

Table 7. Sampling intensity of bluefish length collected from the recreational fishery, by wave, Maine to Florida (east coast).

Samples collected (# fish measured)

	Year							
wave	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Jan-Feb	16	12	68	38	64	49	81	22
Mar-Apr	115	292	283	201	261	127	188	94
May-Jun	680	911	636	577	1,100	579	1,183	910
Jul-Aug	1,575	937	571	563	1,255	863	910	1,577
Sep-Oct	1,363	915	702	825	1,366	1,306	820	1,632
Nov-Dec	643	286	223	167	278	352	309	319
total	4,392	3,353	2,483	2,371	4,324	3,276	3,491	4,554

Landings (00s lbs)

	Year							
wave	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Jan-Feb	1,163	1,638	714	1,430	2,325	1,451	1,564	2,014
Mar-Apr	1,968	4,102	3,719	1,754	4,712	2,237	2,935	4,610
May-Jun	22,781	28,133	19,622	22,152	30,387	20,644	43,281	31,685
Jul-Aug	44,753	50,075	15,134	37,119	46,930	20,909	32,042	46,060
Sep-Oct	47,640	30,267	39,774	38,538	38,885	49,632	41,629	55,144
Nov-Dec	24,713	9,125	3,568	5,065	9,059	18,842	9,908	11,942
total	143,018	123,340	82,531	106,058	132,298	113,715	131,359	151,455

Samples per 00 lbs landed

	Year							
wave	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Jan-Feb	0.014	0.007	0.095	0.027	0.028	0.034	0.052	0.011
Mar-Apr	0.058	0.071	0.076	0.115	0.055	0.057	0.064	0.020
May-Jun	0.030	0.032	0.032	0.026	0.036	0.028	0.027	0.029
Jul-Aug	0.035	0.019	0.038	0.015	0.027	0.041	0.028	0.034
Sep-Oct	0.029	0.030	0.018	0.021	0.035	0.026	0.020	0.030
Nov-Dec	0.026	0.031	0.063	0.033	0.031	0.019	0.031	0.027
total	0.031	0.027	0.030	0.022	0.033	0.029	0.027	0.030

Table 8. Age sample sizes used in development of age length keys.
Spring 1998-2004 VA only. 1997 NC. Autumn 1999-2000 includes VA and NC data.

Spring	**0**	**1**	**2**	**3**	**4**	**5**	**6+**	**total**
1997	-	101	76	19	9	7	16	228
1998	-							0
1999	-							0
2000	-							0
2001	-	12	32	2	2	3	11	62
2002	-	103	85	6	8	42	38	282
2003	-		147	4	13	17	45	226
2004	-	82	131	23	3		2	241

Autumn	**0**	**1**	**2**	**3**	**4**	**5**	**6+**	
1997	65	128	14	1			9	217
1998								0
1999	85	134	59	7	1	2	49	337
2000	21	108	10				1	140
2001		116	109		2	5	40	272
2002	7	319	56	5	1	2	5	395
2003	34	51	12		6	41	70	214
2004		132	28	6				166

Table 9. Total Atlantic coast bluefish catch at age (000s). CAA for 1982 to 1996 adjusted from SAW 23 to reflect updated landings estimates.

	Age						
	0	1	2	3	4	5	6+
1982	11,158	9,746	2,848	2,435	797	1,217	3,746
1983	4,783	7,661	8,675	3,024	972	1,326	4,787
1984	7,140	6,799	6,686	2,046	898	745	3,190
1985	4,680	6,462	5,776	2,928	1,325	520	2,378
1986	5,172	8,045	8,719	2,813	1,060	1,705	4,479
1987	3,122	5,419	5,180	5,750	2,008	1,085	3,959
1988	1,708	2,081	2,517	1,591	1,985	1,599	2,748
1989	3,468	5,671	3,227	990	398	1,173	2,407
1990	2,721	7,198	1,851	691	382	428	2,461
1991	3,710	5,292	7,332	1,619	315	225	2,149
1992	2,118	9,527	1,739	2,407	596	478	993
1993	1,196	2,073	1,575	592	1,036	665	1,187
1994	1,971	3,144	1,313	368	297	850	1,073
1995	1,904	3,257	733	130	203	686	1,122
1996	1,713	2,151	632	204	209	538	1,398
1997	1,634	4,299	1,496	511	197	93	1,212
1998	683	2,754	2,786	861	261	308	459
1999	1,638	1,946	2,097	573	175	353	483
2000	667	4,396	2,693	718	97	536	156
2001	1,414	4,467	3,466	1,152	198	608	243
2002	587	5,146	1,662	543	340	237	416
2003	819	2,646	3,974	774	378	320	644
2004	421	5,149	2,222	1,226	425	461	644

Table 10. Total Atlantic coast bluefish weight at age (lbs).
1996 estimates set equal to 1995

	Age						
	0	**1**	**2**	**3**	**4**	**5**	**6+**
1982	0.14	0.49	1.52	2.05	3.20	4.23	6.57
1983	0.10	0.42	0.99	2.15	3.16	4.42	6.72
1984	0.10	0.41	0.93	1.83	2.91	4.48	7.19
1985	0.10	0.40	0.97	1.93	2.82	3.99	6.42
1986	0.12	0.49	1.20	2.32	3.15	4.30	6.28
1987	0.12	0.30	1.18	2.02	2.96	3.93	5.92
1988	0.17	0.40	1.00	2.05	2.84	3.56	5.59
1989	0.13	0.30	1.06	2.12	3.64	4.11	5.76
1990	0.21	0.50	0.88	1.73	3.24	4.18	5.27
1991	0.14	0.33	0.70	1.73	2.81	3.96	5.78
1992	0.16	0.39	1.04	1.89	2.80	3.30	6.08
1993	0.18	0.59	0.95	2.46	2.73	3.24	6.18
1994	0.12	0.40	0.90	1.88	3.04	3.76	6.15
1995	0.17	0.44	0.98	1.73	2.85	4.06	5.66
1996	0.17	0.44	0.98	1.73	2.85	4.06	5.66
1997	0.13	0.51	1.04	2.22	3.06	4.11	5.58
1998	0.19	0.60	0.94	2.35	3.40	4.02	6.04
1999	0.14	0.53	0.92	2.09	3.43	4.10	5.75
2000	0.17	0.46	1.00	2.72	3.51	3.61	6.02
2001	0.16	0.44	0.91	2.52	3.87	3.88	5.55
2002	0.17	0.55	1.17	2.29	2.90	3.78	5.08
2003	0.12	0.56	1.00	2.17	2.64	3.66	4.65
2004	0.08	0.45	1.32	2.14	3.27	3.75	4.64

Table 11. Bluefish recreational CPUE at age using re-transformed GLM indices.

	Age						
year	**0**	**1**	**2**	**3**	**4**	**5**	**6+**
1982	0.109	0.099	0.027	0.021	0.010	0.015	0.047
1983	0.042	0.061	0.067	0.026	0.009	0.011	0.044
1984	0.094	0.075	0.060	0.027	0.012	0.009	0.045
1985	0.071	0.087	0.087	0.045	0.016	0.008	0.035
1986	0.053	0.066	0.082	0.034	0.013	0.018	0.052
1987	0.035	0.064	0.063	0.065	0.023	0.014	0.052
1988	0.023	0.027	0.031	0.023	0.028	0.023	0.043
1989	0.056	0.085	0.043	0.016	0.005	0.014	0.038
1990	0.038	0.115	0.033	0.012	0.006	0.005	0.029
1991	0.047	0.059	0.060	0.028	0.005	0.003	0.029
1992	0.016	0.050	0.034	0.054	0.013	0.004	0.024
1993	0.022	0.049	0.023	0.013	0.024	0.016	0.016
1994	0.044	0.066	0.030	0.010	0.006	0.013	0.019
1995	0.029	0.092	0.017	0.004	0.006	0.017	0.014
1996	0.059	0.065	0.018	0.007	0.007	0.008	0.024
1997	0.051	0.102	0.035	0.011	0.004	0.002	0.029
1998	0.031	0.077	0.067	0.029	0.010	0.007	0.018
1999	0.116	0.098	0.071	0.029	0.008	0.009	0.017
2000	0.035	0.182	0.089	0.028	0.003	0.012	0.007
2001	0.062	0.162	0.098	0.036	0.006	0.012	0.009
2002	0.031	0.223	0.068	0.021	0.005	0.006	0.016
2003	0.035	0.096	0.135	0.025	0.008	0.010	0.020
2004	0.018	0.157	0.088	0.051	0.013	0.016	0.024

Table 12. Seasonal distribution of fisheries independent surveys evaluated. Highlighted months were chosen.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
MA trawl									**x**			
RI trawl									**x**			
CT trawl				x	x	x			**x**	x		
NY trawl					x	x	x	**x**	**x**	x		
NY beach						x	x	**x**	x	x		
NJ trawl	x			x		x		x		**x**		
DE juv trawl						x	x	x	**x**	x		
DE adult trawl			x	x	x	x	x	**x**	**x**	**x**	x	
MD beach seine							**x**	x	x			
VA blue seine					x	x	x	x	**x**	x		
NMFS inshore			x	x					**x**	**x**		
NMFS offshore			x	x					**x**	**x**		
SEAMAP				**x**	x		x	x		x	x	

Table 13. Mean number per tow or haul from fisheries independent surveys evaluated.

	Massachusetts Bottom Trawl Survey	Rhode Island Trawl Survey	Connecticut LI Sound Trawl Survey	New York Small Trawl Survey	New York Beach Seine Survey	New Jersey Ocean Trawl Survey	Delaware Adult trawl Survey	Delaware Juvenile Trawl Survey	Maryland Beach Seine Survey	Virginia Juvenile Beach Seine Survey	SEAMAP	NEFSC Autumn inshore Trawl Survey	NEFSC Autumn offshore Trawl Survey
1966							0.259						
1967							0.171						
1968							0.047						
1969							0.074						
1970							0.235						
1971							0.357						
1972													
1973													
1974							0.260						
1975												10.043	0.290
1976												64.983	0.549
1977												97.032	0.365
1978	0.354											15.929	0.174
1979	0.059						0.573					53.599	0.241
1980	0.605						0.705	0.026				44.624	0.154
1981	1.372	0.940					0.596	0.000	0.166			287.869	0.716
1982	0.010	0.706					0.379	0.020	0.584			29.706	0.282
1983	0.268	0.845					0.297	0.061	0.526			25.852	0.277
1984	1.094	3.526	54.068		8.723		0.377	0.122	0.289			124.003	0.225
1985	0.566	0.996	39.933		2.130			0.000	0.375			28.748	0.676
1986	1.507	2.950	9.808		10.897			0.387	0.091			22.165	0.268
1987	4.114	6.714	18.230	0.764	6.683			0.121	0.142			10.068	0.278
1988	0.611	1.719	15.411	0.538	6.533	25.324		0.477	0.066			9.636	0.142
1989	0.174	1.311	51.410	0.518	15.264	6.381		0.341	0.311			239.204	0.390
1990	0.324	0.927	32.739	0.318	7.306	3.834	0.759	0.088	0.238		4.531	9.945	0.239
1991	5.442	5.179	44.362	0.352	13.545	12.784	0.394	0.194	0.121		6.808	8.111	0.089
1992	0.000	0.594	30.306	0.125	6.200	3.172	0.240	0.292	0.109		5.098	7.312	0.252
1993	1.604	1.598	30.582	0.114	2.959	2.278	0.629	0.072	0.039		0.828	1.336	0.214
1994	0.580	8.419	33.339	0.200	3.102	8.362	0.320	0.104	0.083	1.211	0.966	7.426	0.324
1995	0.596	2.791	35.574	0.425	2.826	4.846	0.623	0.138	0.063	0.341	7.083	13.576	0.587
1996	0.093	2.753	44.471	0.546	5.055	2.149	0.796	0.225	0.083	0.084	2.161	11.704	0.071
1997	16.501	7.371	41.805	0.179	9.577	2.526	0.546	0.532	0.582	0.554	2.630	5.007	0.152
1998	10.779	14.660	37.021	0.234	2.054	4.982	0.696	0.236	0.120	0.399	1.674	5.316	0.185
1999	1.797	18.749	51.216	0.444	2.256	1.616	1.091	0.266	0.151	0.723	1.604	16.934	0.384
2000	0.172	0.594	27.895	0.310	3.816	1.808	0.548	0.381	0.205	0.197	1.344	4.197	0.339
2001	0.175	2.726	38.895	0.078	13.280	0.778	1.273	0.385	0.247	0.296	0.448	9.748	0.221
2002	0.135	3.393	18.214	0.095	3.253	9.642	0.968	0.321	0.080	0.811	0.929	9.104	0.193
2003	0.110	0.295	28.525	0.019	3.159	5.971	0.269	0.055	0.173		1.517	51.784	0.288
2004		2.322	29.130	0.021	2.804	3.302	0.927	0.053				12.857	0.361
Average	1.886	3.837	33.949	0.293	6.258	5.868	0.515	0.196	0.211	0.513	2.687	41.261	0.298

Table 14. Mean weight (kg) per tow or haul from fisheries independent surveys evaluated.

	Rhode Island Trawl Survey	Connecticut LI Sound Trawl Survey	New Jersey Ocean Trawl Survey	Delaware Adult trawl Survey	SEAMAP	NEFSC Autumn inshore Trawl Survey
1966				0.000		
1967				0.000		
1968				0.000		
1969				0.000		
1970				0.000		
1971				0.000		
1972						
1973						
1974				0.000		
1975						6.108
1976						6.914
1977						8.418
1978						7.156
1979				0.393		8.662
1980				0.365		6.957
1981	0.136			0.386		20.983
1982	0.077			0.269		3.894
1983	0.148			0.179		4.074
1984	0.714	0.000		0.158		9.654
1985	0.214	0.000				4.200
1986	0.346	0.000				3.857
1987	0.721	0.000				3.008
1988	0.274	0.000	12.956			1.504
1989	0.204	0.000	3.417			11.681
1990	0.239	0.000	1.609	0.440	0.860	3.051
1991	0.669	0.000	2.031	0.134	1.106	1.520
1992	0.273	14.125	1.211	0.123	0.891	1.327
1993	0.343	11.376	1.013	0.346	0.145	0.656
1994	0.791	6.650	1.555	0.178	0.273	1.611
1995	0.185	11.081	1.282	0.294	1.248	2.184
1996	0.584	8.352	0.684	0.373	0.382	2.473
1997	0.616	5.977	0.701	0.241	0.559	1.079
1998	0.438	5.004	3.207	0.444	0.319	1.054
1999	1.189	6.755	0.624	0.377	0.357	2.696
2000	0.120	8.093	1.070	0.241	0.285	1.152
2001	0.288	7.224	0.404	0.627	0.101	1.612
2002	0.597	5.843	3.142	0.798	0.258	1.668
2003	0.117	8.991	1.912	0.127	0.262	3.281
2004	0.688	16.390	1.538	0.503		
Average	0.415	5.517	2.256	0.250	0.503	4.567

Table 15. Fisheries independent mean number per tow at age.

NMFS Inshore survey mean number per tow (re-transformed ln values) at age.

	Age						
year	**0**	**1**	**2**	**3**	**4**	**5**	**6+**
1981	181.869	104.537	0.622	0.513	0.109	0.000	0.219
1982	18.768	10.788	0.064	0.053	0.011	0.000	0.023
1983	8.189	16.695	0.845	0.034	0.004	0.017	0.068
1984	81.356	40.869	1.257	0.201	0.120	0.052	0.147
1985	17.473	9.703	0.925	0.428	0.096	0.036	0.088
1986	21.055	0.923	0.042	0.060	0.024	0.028	0.033
1987	7.589	1.768	0.167	0.238	0.098	0.049	0.158
1988	9.493	0.067	0.009	0.010	0.028	0.006	0.023
1989	237.573	1.254	0.113	0.130	0.000	0.014	0.119
1990	6.186	3.637	0.006	0.016	0.016	0.000	0.084
1991	7.878	0.154	0.050	0.026	0.001	0.000	0.001
1992	6.625	0.637	0.016	0.022	0.002	0.002	0.008
1993	1.109	0.123	0.044	0.003	0.034	0.023	0.000
1994	6.580	0.760	0.010	0.019	0.030	0.021	0.006
1995	9.222	4.122	0.115	0.015	0.015	0.025	0.062
1996	9.643	1.638	0.211	0.144	0.027	0.021	0.019
1997	4.179	0.482	0.217	0.107	0.002	0.007	0.013
1998	4.793	0.387	0.074	0.045	0.017	0.000	0.000
1999	15.266	1.528	0.061	0.051	0.018	0.002	0.008
2000	2.485	1.517	0.157	0.017	0.015	0.006	0.000
2001	8.819	0.754	0.148	0.020	0.002	0.001	0.003
2002	7.815	1.210	0.042	0.037	0.000	0.000	0.000
2003	48.332	3.085	0.277	0.019	0.006	0.022	0.043
2004	7.0484	5.3070	0.3717	0.0788	0.0078	0.0119	0.0314

NMFS Offshore survey mean number per tow (re-transformed ln values) at age

	Age						
year	**0**	**1**	**2**	**3**	**4**	**5**	**6+**
1982	0.010	0.064	0.051	0.056	0.018	0.019	0.065
1983	0.013	0.024	0.064	0.084	0.019	0.022	0.050
1984	0.065	0.045	0.025	0.029	0.010	0.019	0.031
1985	0.084	0.198	0.232	0.050	0.023	0.025	0.064
1986	0.025	0.044	0.031	0.030	0.020	0.028	0.090
1987	0.001	0.006	0.014	0.042	0.045	0.026	0.145
1988	0.001	0.001	0.001	0.006	0.014	0.023	0.097
1989	0.135	0.232	0.000	0.000	0.001	0.006	0.015
1990	0.059	0.063	0.001	0.001	0.006	0.014	0.096
1991	0.001	0.008	0.011	0.022	0.006	0.001	0.040
1992	0.001	0.008	0.008	0.076	0.059	0.044	0.057
1993	0.000	0.000	0.000	0.051	0.099	0.019	0.045
1994	0.000	0.000	0.000	0.000	0.026	0.166	0.132
1995	0.151	0.117	0.020	0.071	0.046	0.122	0.060
1996	0.000	0.000	0.015	0.007	0.004	0.036	0.009
1997	0.030	0.000	0.000	0.013	0.027	0.051	0.030
1998	0.037	0.032	0.005	0.034	0.043	0.012	0.021
1999	0.018	0.037	0.044	0.057	0.098	0.048	0.083
2000	0.003	0.252	0.022	0.027	0.009	0.011	0.015
2001	0.003	0.042	0.037	0.090	0.015	0.015	0.020
2002	0.000	0.011	0.025	0.075	0.033	0.025	0.024
2003	0.197	0.060	0.007	0.005	0.002	0.008	0.010
2004	0.000	0.056	0.054	0.077	0.033	0.071	0.070

Connecticut Long Island trawl survey geometric mean number per tow at age.

	Age						
year	**0**	**1**	**2**	**3**	**4**	**5**	**6+**
1984	52.101	0.800	0.760	0.298	0.054	0.014	0.041
1985	36.368	1.573	1.075	0.498	0.244	0.044	0.131
1986	8.727	0.547	0.352	0.083	0.053	0.028	0.018
1987	14.357	2.229	0.951	0.279	0.213	0.131	0.070
1988	13.122	0.851	0.567	0.358	0.234	0.173	0.106
1989	47.873	1.900	0.732	0.205	0.347	0.282	0.072
1990	28.027	3.499	0.742	0.106	0.141	0.200	0.024
1991	36.482	5.233	2.078	0.194	0.135	0.164	0.075
1992	24.585	3.359	1.750	0.172	0.152	0.283	0.005
1993	25.810	1.241	2.161	0.877	0.385	0.107	0.000
1994	30.018	1.410	0.752	0.512	0.386	0.251	0.010
1995	26.588	6.967	1.313	0.303	0.168	0.202	0.034
1996	42.334	0.491	1.031	0.360	0.060	0.036	0.159
1997	40.413	0.586	0.536	0.140	0.051	0.022	0.058
1998	34.831	1.453	0.512	0.130	0.058	0.011	0.025
1999	44.950	5.617	0.287	0.188	0.046	0.049	0.079
2000	22.593	3.652	1.408	0.178	0.021	0.016	0.029
2001	34.050	2.294	2.180	0.283	0.026	0.021	0.042
2002	12.419	4.926	0.578	0.135	0.045	0.048	0.063
2003	27.307	0.357	0.655	0.104	0.024	0.034	0.044
2004	20.134	3.944	3.315	1.336	0.071	0.160	0.171

Table 15. (cont.) Fisheries independent mean number per tow at age.

NJ Ocean Trawl survey geometric mean number per tow at age.

year	Age 0	1	2	3	4	5	6+
1988	23.969	0.378	0.002				
1989	5.327	0.411	0.020				
1990	3.636	0.183	0.003				
1991	12.459	0.029	0.067				
1992	2.700	0.419	0.029				
1993	2.065	0.070	0.090				
1994	8.323	0.172	0.012				
1995	4.560	0.215	0.045				
1996	2.017	0.078	0.012				
1997	2.440	0.046	0.021				
1998	4.196	0.408	0.233	0.111	0.020	0.003	0.010
1999	1.322	0.270	0.027	0.001	0.000	0.000	0.000
2000	1.308	0.366	0.095	0.036	0.002	0.000	0.000
2001	0.523	0.089	0.117	0.012	0.009	0.009	0.019
2002	6.649	2.911	0.064	0.011	0.003	0.003	0.000
2003	5.723	0.165	0.065	0.004	0.002	0.004	0.009
2004	2.182	0.708	0.322	0.033	0.012	0.027	0.020

DE Adult Trawl survey geometric mean number per tow at age.

year	Age 0	1	2
1990	0.299	0.450	0.009
1991	0.135	0.254	0.000
1992	0.000	0.237	0.003
1993	0.436	0.301	0.037
1994	0.005	0.314	0.000
1995	0.168	0.438	0.017
1996	0.436	0.337	0.023
1997	0.218	0.308	0.020
1998	0.191	0.439	0.066
1999	0.722	0.355	0.014
2000	0.205	0.309	0.034
2001	0.839	0.395	0.040
2002	0.444	0.509	0.016
2003	0.000	0.260	0.009
2004	0.281	0.631	0.015

Table 16. Fisheries independent indices of age-0 bluefish by cohort as determined from length distributions.

	Massachusetts Bottom Trawl Survey		Rhode Island Trawl Survey		Connecticut LI Sound Trawl Survey		New York Small Trawl Survey		New Jersey Ocean Trawl Survey		Delaware Adult trawl Survey		Delaware Juvenile Trawl Survey		VA Juvenile Beach Seine Survey	SEAMAP survey	NMFS Fall Inshore Survey		NMFS Fall Offshore Survey	
age 0	spring	summer	spring	summer	spring	summer	spring	summer	spring	summer	spring	summer	spring	summer	summer	summer	spring	summer	spring	summer
1975																	8.585	0.157	0.046	0.000
1976																	58.751	2.427	0.284	0.000
1977																	92.383	3.174	0.219	0.017
1978	0.104	0.250															6.835	1.696	0.002	0.000
1979	0.011	0.048									0.367	0.000					49.922	0.828	0.003	0.000
1980	0.000	0.605									0.302	0.000	0.026	0.000			35.993	3.875	0.026	0.000
1981	0.173	1.199	0.678	0.263							0.072	0.000	0.000	0.000			261.778	13.787	0.645	0.000
1982	0.000	0.011	0.151	0.555							0.067	0.000	0.020	0.000			25.722	1.445	0.005	0.000
1983	0.194	0.073	0.680	0.165							0.000	0.000	0.020	0.020			22.711	0.656	0.069	0.000
1984	0.725	0.368	3.375	0.141	41.071	10.831					0.157	0.000	0.082	0.041			109.917	6.642	0.104	0.000
1985	0.319	0.247	0.402	0.507	34.328	1.341							0.000	0.000			22.747	1.291	0.131	0.000
1986	1.226	0.281	1.854	1.029	7.531	0.305							0.290	0.097			17.791	3.190	0.060	0.000
1987	0.373	3.741	4.796	1.907	11.778	3.720	0.442	0.318					0.100	0.020			7.254	0.131	0.000	0.000
1988	0.258	0.353	1.018	0.692	11.150	3.049	0.362	0.176	10.016	13.953			0.143	0.334			3.061	6.374	0.000	0.000
1989	0.035	0.139	1.109	0.179	44.069	4.890	0.265	0.253	4.659	0.666			0.052	0.288			216.002	14.577	0.351	0.000
1990	0.021	0.304	0.665	0.229	25.514	1.293	0.183	0.135	3.495	0.136	0.276	0.000	0.035	0.053		4.531	4.166	1.768	0.116	0.000
1991	0.216	5.226	1.545	3.547	30.842	7.066	0.262	0.090	2.998	9.525	0.158	0.000	0.123	0.053		6.808	7.761	0.047	0.007	0.000
1992	0.000	0.000	0.041	0.483	15.590	7.094	0.048	0.068	0.873	1.847	0.000	0.000	0.102	0.190		5.098	1.231	5.374	0.000	0.000
1993	0.648	0.956	1.119	0.445	23.866	3.271	0.101	0.013	1.869	0.197	0.441	0.000	0.054	0.018		0.828	0.968	0.046	0.000	0.000
1994	0.440	0.140	4.090	4.329	17.025	14.900	0.116	0.084	1.999	6.327	0.000	0.000	0.035	0.069	1.199	0.966	3.671	2.739	0.000	0.000
1995	0.042	0.554	0.113	2.669	25.200	6.369	0.300	0.125	3.439	1.160	0.161	0.000	0.069	0.069	0.341	7.083	5.268	3.613	0.034	0.024
1996	0.036	0.057	2.686	0.033	41.862	0.475	0.289	0.257	1.796	0.236	0.381	0.000	0.225	0.000	0.075	2.161	9.157	0.155	0.000	0.000
1997	0.118	16.383	0.805	6.563	12.251	28.164	0.079	0.100	1.247	1.193	0.211	0.000	0.208	0.324	0.554	2.630	2.363	1.801	0.022	0.008
1998	0.424	10.356	0.876	13.768	11.457	24.353	0.018	0.212	1.826	2.478	0.226	0.000	0.029	0.206	0.399	1.674	2.628	2.178	0.028	0.000
1999	0.362	1.435	1.602	17.117	36.130	14.169	0.016	0.428	1.111	0.333	0.873	0.034	0.100	0.166	0.712	1.604	11.897	3.791	0.022	0.000
2000	0.091	0.081	0.111	0.477	24.718	1.258	0.163	0.144	1.242	0.295	0.219	0.044	0.030	0.350	0.197	1.344	1.804	0.770	0.000	0.000
2001	0.112	0.064	0.166	2.478	29.749	5.911	0.063	0.010	0.255	0.304	0.861	0.047	0.160	0.224	0.296	0.448	3.390	5.686	0.000	0.000
2002	0.037	0.099	0.225	2.978	12.579	3.015	0.005	0.090	6.642	1.610	0.562	0.000	0.092	0.214	0.802	0.929	2.448	5.693	0.000	0.000
2003	0.111	0.000	0.134	0.081	25.630	1.710	0.012	0.000	3.786	2.052	0.073	0.000	0.018	0.037	-	1.517	27.846	21.886	0.235	0.000
2004	0.033	0.256	0.116	1.963			0.008	0.008	2.167	0.339	0.456	0.000	0.053	0.000	0.440		6.076	1.768	0.000	0.000

spring and summer cohorts (not survey period)

division by length
summer = 1-13 cm
spring=14-25 cm
(unless otherwise obvious breaks in length frequency for upper end of spring)

Table 17. Correlations among juvenile indices by cohort group.

Survey	cohort	MA trawl spring	MA trawl summer	RI trawl spring	RI trawl summer	CT trawl spring	CT trawl summer	NY trawl spring	NY trawl summer	NJ trawl spring	NJ trawl summer	DE Adult trawl spring	DE Adult trawl summer	DE Juv Trawl spring	DE Juv Trawl summer	VA Seine summer	SEAMAP summer	NMFS Inshore spring	NMFS Inshore summer	NMFS Offshore spring	REC CPUE age 0	REC CPUE age 1
MA trawl	spring	1.00																				
MA trawl	summer	0.01	1.00																			
RI trawl	spring	0.46	0.03	1.00																		
RI trawl	summer	0.10	**0.50**	0.06	1.00																	
CT trawl	spring	-0.23	-0.35	0.02	-0.11	1.00																
CT trawl	summer	0.03	**0.82**	0.10	**0.71**	-0.22	1.00															
NY trawl	spring	-0.05	-0.13	0.48	-0.42	0.11	-0.39	1.00														
NY trawl	summer	0.11	0.06	0.45	**0.51**	0.26	0.12	0.35	1.00													
NJ trawl	spring	-0.11	-0.23	-0.09	-0.28	-0.25	-0.34	0.45	0.03	1.00												
NJ trawl	summer	0.22	0.02	0.28	-0.07	-0.35	0.00	0.45	-0.07	**0.62**	1.00											
DE Adult trawl	spring	0.06	-0.06	-0.09	0.43	0.29	-0.09	-0.27	0.37	-0.12	-0.44	1.00										
DE Adult trawl	summer	-0.08	-0.17	-0.21	0.24	0.25	-0.13	-0.17	0.22	-0.49	-0.33	**0.63**	1.00									
DE Juv Trawl	spring	0.34	0.23	0.21	0.03	-0.21	0.02	0.22	0.13	-0.04	0.12	0.40	0.11	1.00								
DE Juv Trawl	summer	-0.21	0.32	-0.33	0.25	-0.26	0.31	-0.17	0.05	0.21	0.13	0.29	**0.55**	0.20	1.00							
VA Seine	summer	**0.57**	-0.01	0.49	0.30	-0.46	0.35	-0.49	-0.07	0.31	**0.78**	-0.13	-0.28	-0.35	-0.09	1.00						
SEAMAP	summer	-0.39	0.06	-0.18	-0.16	0.09	-0.08	**0.62**	-0.01	0.14	0.36	-0.44	-0.38	0.06	-0.26	-0.26	1.00					
NMFS Inshore	spring	0.01	-0.17	0.11	-0.21	**0.56**	-0.06	0.18	0.24	0.19	-0.14	-0.20	-0.16	-0.15	0.11	-0.07	-0.05	1.00				
NMFS Inshore	summer	-0.15	-0.22	-0.21	-0.14	0.19	-0.14	-0.24	-0.20	0.32	-0.02	-0.06	-0.03	-0.15	0.18	0.38	-0.18	**0.51**	1.00			
NMFS Offshore	spring	-0.07	-0.17	-0.13	-0.23	0.46	-0.18	0.01	0.04	0.20	-0.20	-0.27	-0.24	-0.30	-0.01	-0.08	0.03	**0.80**	**0.72**	1.00		
REC CPUE	age 0	0.12	-0.09	0.14	0.28	**0.61**	0.17	-0.17	**0.58**	-0.33	-0.24	0.32	0.27	0.01	-0.22	0.10	-0.22	0.29	-0.04	0.10	1.00	
REC CPUE	age 1	-0.35	-0.07	-0.39	0.06	0.01	-0.09	-0.41	-0.16	-0.07	-0.46	0.47	**0.52**	-0.11	0.35	-0.05	-0.37	-0.08	0.08	-0.04	0.07	1.00

Table 18. Atlantic coast bluefish biological reference points.

ASAP Reference Points using final year selectivity scales Max=1.0

Ref pt	F	slope to plot on SRR
F0.1	0.177	0.184
Fmax	0.276	0.264
F30%SPR	0.279	0.267
F40%SPR	0.199	0.200
Fmsy	**0.190**	0.193
Foy	0.143	-------
Fcurrent	0.146	0.162
SSmsy	142,104	
Rmsy	30,777	
SSoy	180,341	
MSY	18,483	
OY	17,881	
SSmsy_ratio	0.487	
Fmsy_ratio	0.769	
Bmsy ratio	0.701	

Thompson-Bell YPR

age 0		1982-2003 PR Time series average
	0	0.337
	1	0.996
	2	0.934
	3	0.468
	4	0.337
	5	0.696
	6	0.910
	7+	1.000

	F	Catch Wt (YPR)	SSB/R	% MSP
F max	0.254	0.722	3.04	30.3
F 0.1	0.173	0.689	4.29	42.9
$F_{30\%}$	0.257	0.722	3.00	30.0
Fmsy	0.190		3.97	
Bmsy	**147,052** (from stock/recruit and recruitment at F=0.19)			

F_{msy} =	**0.19**
F_{2004} =	**0.15**
B_{msy} =	**147,052**
B_{2004} =	**92,337**

Table19. Fishing mortality at age estimates from ADAPT model.

	Age							
year	**0**	**1**	**2**	**3**	**4**	**5**	**6+**	**F_{2-4}**
1982	0.274	0.274	0.280	0.378	0.152	0.270	0.378	0.270
1983	0.112	0.307	0.417	0.540	0.254	0.404	0.565	0.404
1984	0.138	0.230	0.480	0.162	0.303	0.315	0.441	0.315
1985	0.152	0.179	0.312	0.400	0.150	0.287	0.402	0.287
1986	0.282	0.420	0.387	0.246	0.246	0.293	0.410	0.293
1987	0.159	0.536	0.527	0.479	0.278	0.428	0.599	0.428
1988	0.059	0.152	0.515	0.302	0.301	0.373	0.522	0.373
1989	0.087	0.281	0.370	0.392	0.114	0.292	0.409	0.292
1990	0.090	0.261	0.139	0.125	0.257	0.174	0.243	0.174
1991	0.132	0.252	0.462	0.173	0.077	0.237	0.332	0.237
1992	0.262	0.576	0.123	0.270	0.089	0.160	0.224	0.160
1993	0.112	0.441	0.172	0.056	0.178	0.135	0.190	0.135
1994	0.149	0.473	0.559	0.055	0.036	0.217	0.303	0.217
1995	0.121	0.391	0.190	0.096	0.039	0.108	0.152	0.108
1996	0.087	0.194	0.121	0.074	0.219	0.138	0.193	0.138
1997	0.116	0.327	0.201	0.136	0.095	0.144	0.201	0.144
1998	0.043	0.290	0.365	0.170	0.095	0.210	0.294	0.210
1999	0.068	0.165	0.374	0.118	0.047	0.180	0.252	0.180
2000	0.036	0.261	0.360	0.211	0.026	0.199	0.279	0.199
2001	0.039	0.349	0.338	0.257	0.083	0.226	0.317	0.226
2002	0.022	0.191	0.211	0.081	0.112	0.135	0.188	0.135
2003	0.020	0.133	0.221	0.144	0.074	0.146	0.205	0.146
2004	0.028	0.170	0.158	0.098	0.110	0.128	0.179	0.122

Table 20. January 1 population size estimates (000s) from the ADAPT model.

year	Age 0	1	2	3	4	5	6+	Total
1982	51,171	44,730	12,803	8,487	6,219	5,648	13,049	142,107
1983	49,712	31,862	27,857	7,922	4,763	4,373	12,118	138,606
1984	60,939	36,388	19,201	15,025	3,778	3,025	9,800	148,157
1985	36,564	43,458	23,674	9,728	10,459	2,286	7,868	134,037
1986	23,121	25,719	29,760	14,191	5,337	7,369	14,584	120,081
1987	23,321	14,279	13,840	16,539	9,088	3,416	9,598	90,082
1988	32,968	16,281	6,839	6,693	8,388	5,635	7,392	84,195
1989	45,852	25,451	11,455	3,345	4,050	5,083	7,860	103,095
1990	34,854	34,412	15,738	6,481	1,850	2,957	12,534	108,827
1991	33,128	26,082	21,700	11,217	4,683	1,171	8,343	106,325
1992	10,101	23,780	16,593	11,194	7,726	3,550	5,428	78,372
1993	12,475	6,365	10,945	12,018	7,000	5,787	7,562	62,153
1994	15,639	9,135	3,353	7,542	9,306	4,798	4,505	54,277
1995	18,468	11,029	4,661	1,570	5,843	7,351	8,766	57,687
1996	22,568	13,404	6,107	3,156	1,167	4,600	8,755	59,757
1997	16,475	16,933	9,037	4,430	2,400	768	7,314	57,357
1998	17,940	12,015	10,000	6,052	3,167	1,788	1,977	52,940
1999	27,464	14,071	7,362	5,686	4,179	2,357	2,385	63,504
2000	21,048	21,007	9,767	4,145	4,139	3,264	704	64,074
2001	41,289	16,630	13,245	5,578	2,747	3,301	985	83,775
2002	29,237	32,528	9,604	7,731	3,531	2,071	2,664	87,365
2003	45,106	23,407	21,998	6,367	5,840	2,584	3,822	109,124
2004	16,545	36,190	16,780	14,433	4,515	4,440	4,313	97,216
2005	28,548	13,166	24,991	11,736	10,712	3,313	6,149	98,616

Table 21. Population biomass estimates (000s lbs) from ADAPT model

	Age							
year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**Total**
1982	4,135	15,418	16,363	14,014	16,938	20,786	64,698	152,351
1983	2,456	7,726	19,403	14,321	12,122	16,441	67,582	140,050
1984	3,047	7,369	12,000	20,224	9,451	11,387	55,368	118,845
1985	1,653	8,692	14,929	13,033	23,759	7,790	39,758	109,614
1986	1,755	5,694	20,618	21,289	13,161	25,669	70,701	158,886
1987	1,532	2,709	10,524	25,750	23,815	12,015	47,836	124,181
1988	4,220	3,567	3,746	10,410	20,090	18,304	34,171	94,508
1989	3,040	5,747	7,459	4,870	11,064	17,358	37,100	86,637
1990	5,838	8,775	8,086	8,776	4,848	11,532	56,078	103,934
1991	2,779	6,865	12,838	13,840	10,325	4,196	41,423	92,267
1992	841	5,557	9,720	12,876	17,003	10,814	27,721	84,533
1993	1,506	1,955	6,662	19,223	15,901	17,424	36,905	99,576
1994	981	2,451	2,443	10,079	25,448	15,365	18,437	75,204
1995	1,952	2,534	2,918	1,959	13,525	25,818	41,166	89,873
1996	2,214	3,666	4,010	4,109	2,592	15,644	41,114	73,350
1997	997	4,985	6,114	6,534	5,522	2,628	33,643	60,423
1998	2,042	3,356	6,924	9,461	8,700	6,270	10,638	47,391
1999	2,120	4,465	5,470	7,970	11,865	8,801	12,328	53,019
2000	2,225	5,332	7,111	6,557	11,210	11,485	3,968	47,888
2001	3,563	4,548	8,570	8,856	8,914	12,183	5,346	51,980
2002	2,740	9,648	6,891	11,160	9,545	7,919	12,415	60,317
2003	2,797	7,221	16,314	10,145	14,359	8,419	15,707	74,962
2004	455	8,410	14,427	21,114	12,027	13,971	20,010	90,415

Table 22. Diagnostic information from preferred ASAP model run.

Component	Residual Sum Squares	Number Obs	Index Lambda	Likelihood value
Catch_Fleet_Total	0.0035	23	2000	7.058
CAA_proportions	N/A	161	see_below	203.9

objective function = 10116.6

Component	Residual Sum Squares	Number Obs	Index Lambda	Likelihood value
NEFSC 0	16.26	23	50	406.470
NEFSC 1	31.98	23	50	799.479
NEFSC 2	32.35	23	50	808.701
NEFSC 3	21.98	23	50	549.431
NEFSC 4	25.34	21	50	633.618
NEFSC 5	17.08	18	50	427.067
NEFSC 6	25.04	19	50	625.882
DE 0	17.51	13	50	437.674
DE 1	1.97	15	50	49.229
DE 2	8.29	13	50	207.237
NJ 0	14.46	17	50	361.496
NJ 1	15.78	17	50	394.376
NJ 2	23.95	17	50	598.866
CT 0	4.81	21	50	120.240
CT 1	17.05	21	50	426.235
CT 2	10.16	21	50	254.104
CT 3	12.35	21	50	308.684
CT 4	18.79	21	50	469.680
CT 5	24.95	21	50	623.822
CT 6	13.83	20	50	345.860
Rec CPUE 0	3.65	23	50	91.235
Rec CPUE 1	6.07	23	50	151.709
Rec CPUE 2	4.65	23	50	116.340
Rec CPUE 3	3.72	23	50	92.924
Rec CPUE 4	4.32	23	50	107.904
Rec CPUE 5	4.61	23	50	115.254
Rec CPUE 6	2.68	23	50	67.015
SEAMAP	12.90	14	50	322.448
Index_Fit_Total	396.52	563	1400	9912.980

Table 23. Fishing mortality at age estimates from ASAP catch at age model.

	Age							
year	**0**	**1**	**2**	**3**	**4**	**5**	**6+**	**F mult**
1982	0.094	0.279	0.263	0.133	0.096	0.194	0.255	0.279
1983	0.105	0.311	0.293	0.148	0.106	0.216	0.284	0.311
1984	0.094	0.277	0.261	0.132	0.095	0.192	0.254	0.277
1985	0.089	0.263	0.247	0.125	0.090	0.182	0.240	0.263
1986	0.145	0.429	0.404	0.204	0.147	0.297	0.392	0.429
1987	0.155	0.458	0.431	0.218	0.157	0.318	0.419	0.458
1988	0.137	0.406	0.383	0.193	0.139	0.282	0.372	0.406
1989	0.118	0.349	0.328	0.166	0.119	0.242	0.319	0.349
1990	0.108	0.320	0.301	0.152	0.110	0.222	0.293	0.320
1991	0.139	0.411	0.387	0.196	0.141	0.285	0.376	0.411
1992	0.117	0.346	0.326	0.165	0.119	0.240	0.317	0.346
1993	0.113	0.333	0.314	0.159	0.114	0.231	0.305	0.333
1994	0.103	0.304	0.286	0.145	0.104	0.211	0.278	0.304
1995	0.084	0.248	0.233	0.118	0.085	0.172	0.227	0.248
1996	0.082	0.241	0.227	0.115	0.083	0.167	0.221	0.241
1997	0.095	0.280	0.264	0.133	0.096	0.194	0.256	0.280
1998	0.077	0.229	0.216	0.109	0.078	0.159	0.210	0.229
1999	0.068	0.201	0.189	0.096	0.069	0.140	0.184	0.201
2000	0.068	0.200	0.189	0.095	0.069	0.139	0.183	0.200
2001	0.076	0.223	0.210	0.106	0.077	0.155	0.204	0.223
2002	0.060	0.176	0.166	0.084	0.060	0.122	0.161	0.176
2003	0.065	0.191	0.180	0.091	0.066	0.133	0.175	0.191
2004	0.049	0.146	0.138	0.070	0.050	0.102	0.134	0.146
selectivity at age	0.338	1.000	0.942	0.476	0.343	0.694	0.915	

Table 24. January 1 population size estimates (000s) from the ASAP model.

	Age							
year	0	1	2	3	4	5	6+	Total
1982	61,381	50,364	14,431	6,956	6,952	14,105	21,385	175,573
1983	48,325	45,730	31,202	9,087	4,987	5,173	23,083	167,586
1984	52,904	35,618	27,444	19,066	6,417	3,671	17,638	162,757
1985	31,079	39,437	22,103	17,308	13,681	4,778	13,686	142,071
1986	23,235	23,281	24,827	14,129	12,504	10,236	12,070	120,281
1987	16,488	16,455	12,418	13,577	9,433	8,839	12,902	90,112
1988	22,043	11,561	8,522	6,605	8,938	6,601	12,214	76,484
1989	50,783	15,729	6,306	4,759	4,457	6,367	10,973	99,374
1990	23,044	36,951	9,087	3,718	3,301	3,238	10,622	89,960
1991	26,916	16,932	21,973	5,505	2,614	2,422	8,614	84,975
1992	13,379	19,175	9,190	12,214	3,706	1,859	6,332	65,855
1993	15,932	9,744	11,108	5,432	8,481	2,695	4,975	58,367
1994	18,428	11,654	5,718	6,646	3,795	6,195	4,755	57,191
1995	18,179	13,615	7,044	3,518	4,709	2,800	7,058	56,922
1996	18,458	13,687	8,701	4,567	2,560	3,542	6,537	58,052
1997	16,362	13,929	8,806	5,677	3,334	1,930	6,746	56,783
1998	24,271	12,185	8,617	5,537	4,068	2,480	5,575	62,732
1999	27,884	18,390	7,934	5,686	4,065	3,079	5,434	72,472
2000	16,711	21,328	12,314	5,375	4,231	3,107	5,893	68,958
2001	34,542	12,785	14,291	8,348	4,000	3,234	6,230	83,429
2002	27,780	26,221	8,372	9,480	6,145	3,034	6,425	87,457
2003	41,561	21,429	18,004	5,807	7,138	4,737	6,677	105,353
2004	15,850	31,893	14,488	12,309	4,340	5,473	7,984	92,337

Table 25. Population biomass estimates (000s lbs) from ASAP model

	Age							
year	0	1	2	3	4	5	6+	Total
1982	4,960	17,360	18,444	11,485	18,933	51,909	106,028	229,120
1983	2,387	11,089	21,733	16,426	12,692	19,448	128,733	212,508
1984	2,645	7,213	17,152	25,664	16,052	13,817	99,649	182,192
1985	1,405	7,888	13,938	23,188	31,078	16,281	69,157	162,934
1986	1,764	5,154	17,200	21,196	30,834	35,657	58,514	170,318
1987	1,083	3,122	9,442	21,138	24,719	31,090	64,303	154,897
1988	2,822	2,533	4,668	10,273	21,407	21,443	56,461	119,605
1989	3,367	3,552	4,106	6,929	12,175	21,742	51,793	103,664
1990	3,860	9,422	4,669	5,034	8,649	12,627	47,525	91,787
1991	2,258	4,457	12,999	6,792	5,763	8,678	42,769	83,716
1992	1,114	4,481	5,383	14,049	8,156	5,662	32,339	71,185
1993	1,923	2,993	6,761	8,688	19,266	8,114	24,279	72,025
1994	1,156	3,127	4,166	8,882	10,378	19,839	19,459	67,007
1995	1,921	3,128	4,410	4,389	10,901	9,835	33,144	67,728
1996	1,811	3,743	5,713	5,946	5,685	12,046	30,700	65,644
1997	990	4,100	5,958	8,374	7,671	6,603	31,031	64,727
1998	2,763	3,403	5,966	8,657	11,174	8,695	29,999	70,657
1999	2,152	5,835	5,895	7,970	11,542	11,497	28,086	72,978
2000	1,767	5,413	8,965	8,503	11,458	10,932	33,218	80,255
2001	2,981	3,496	9,247	13,253	12,981	11,935	33,814	87,707
2002	2,603	7,777	6,007	13,685	16,611	11,600	29,944	88,228
2003	2,577	6,611	13,352	9,253	17,551	15,432	27,439	92,216
2004	436	7,411	12,457	18,007	11,562	17,222	37,041	104,136

BLUEFISH FIGURES

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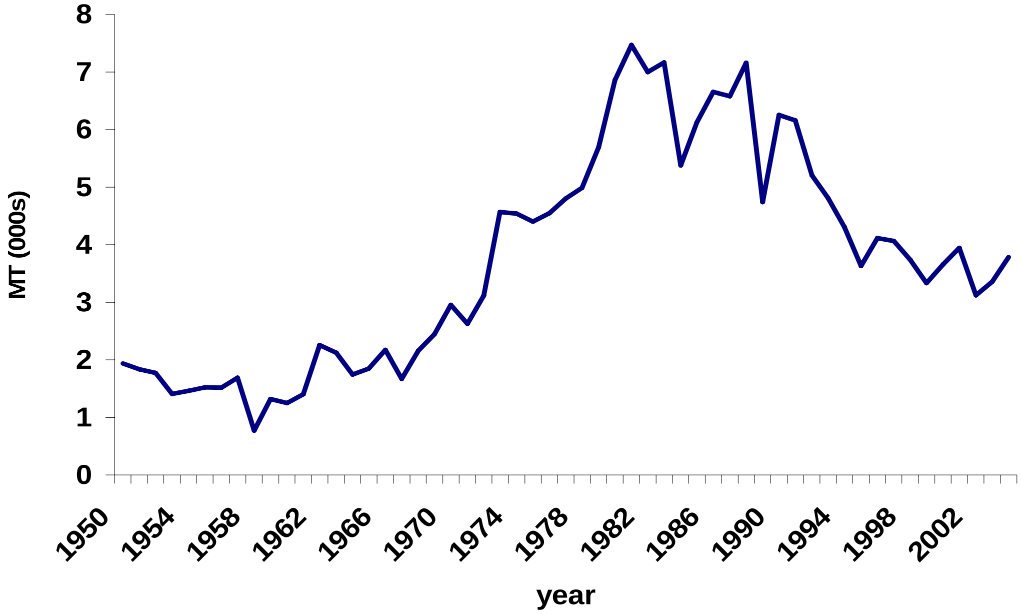

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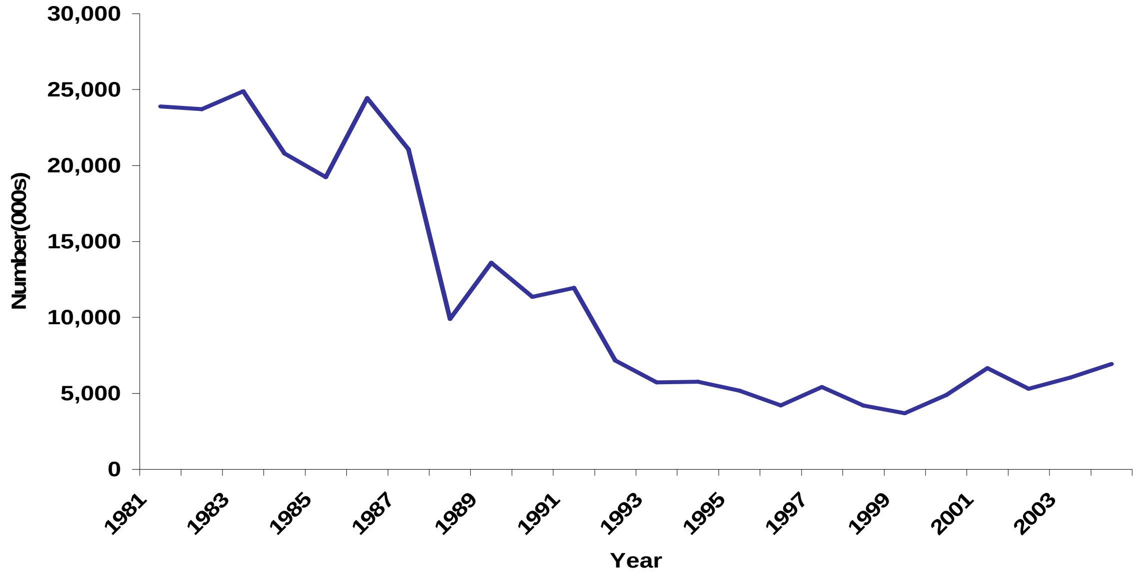

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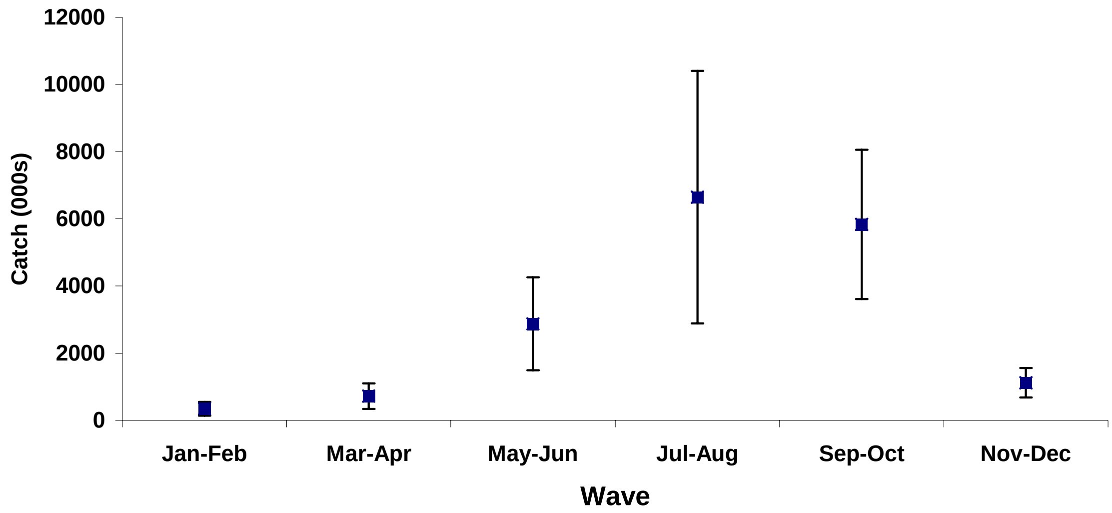

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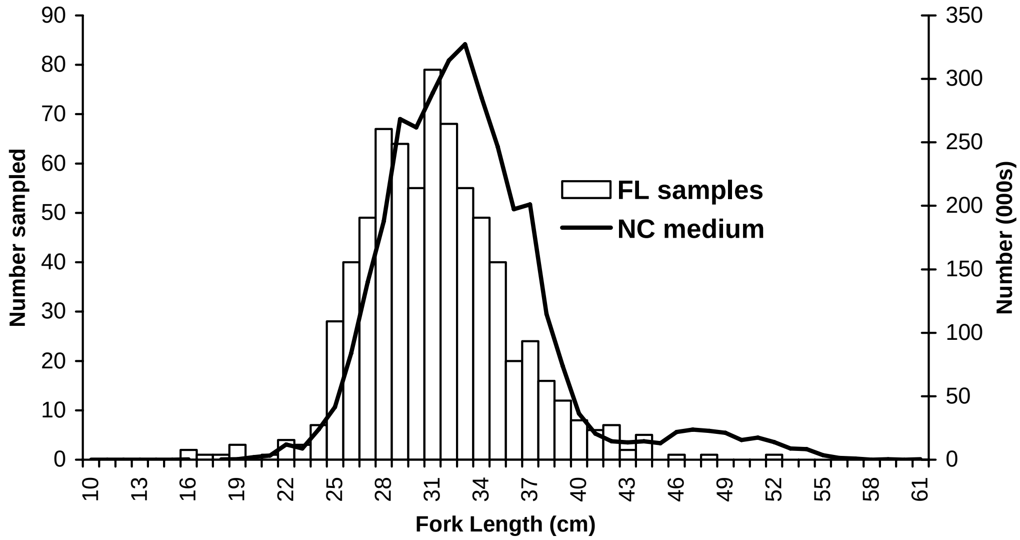

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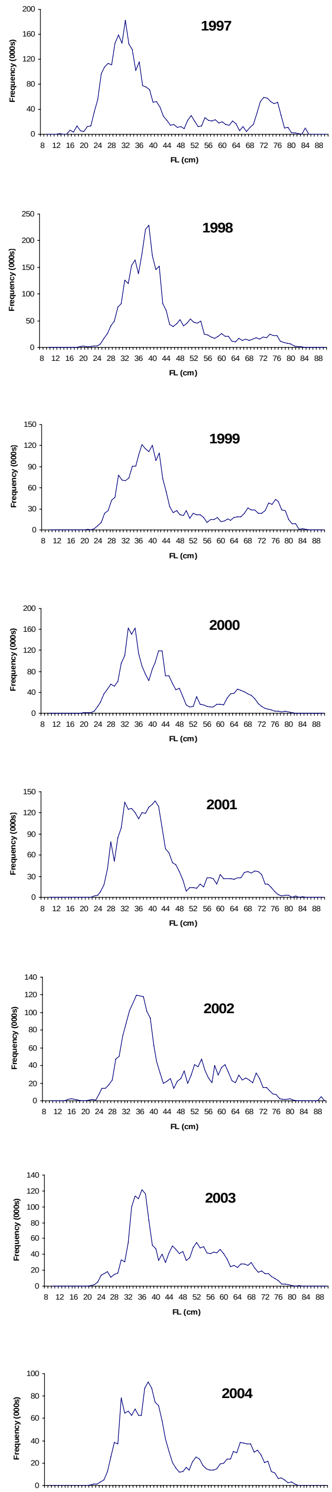

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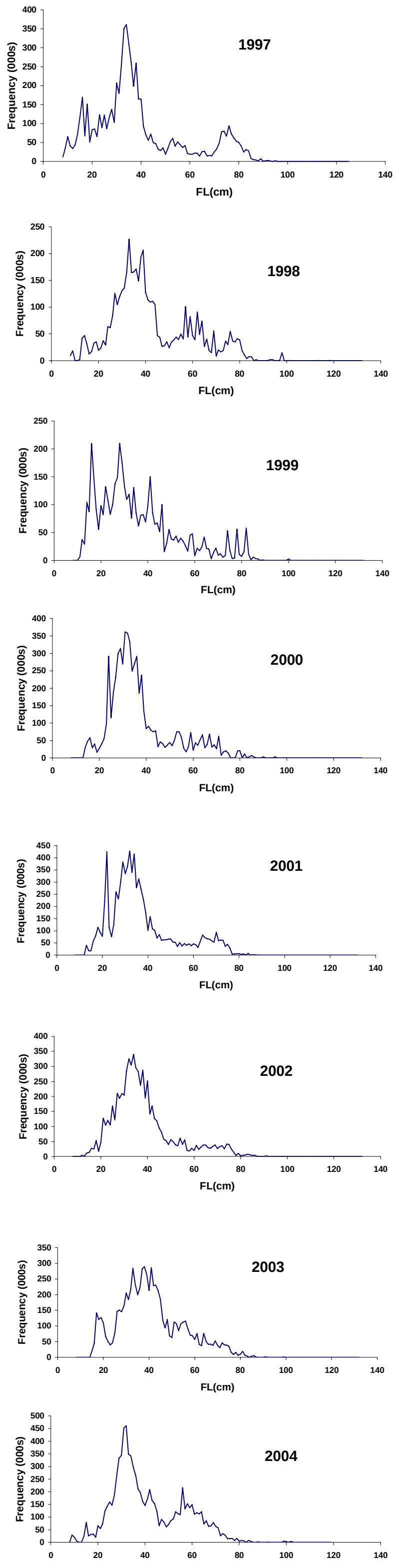

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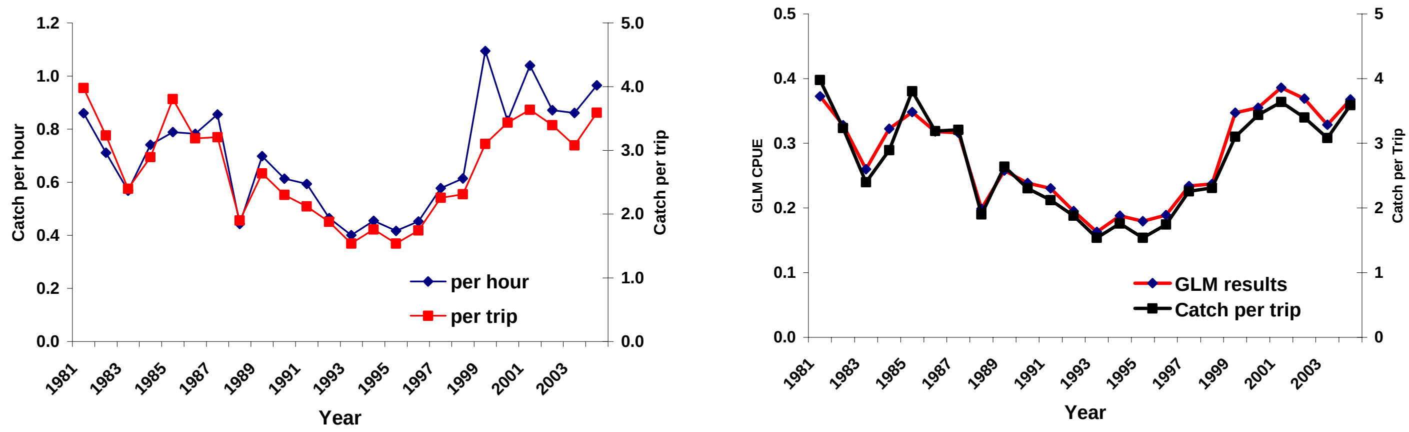
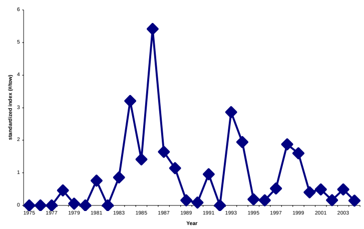


Figure 7. Bluefish recreational catch per effort from MFRSS estimates.

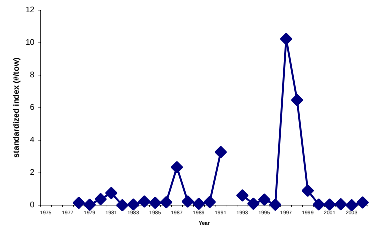
Spring cohorts

MA fall trawl survey

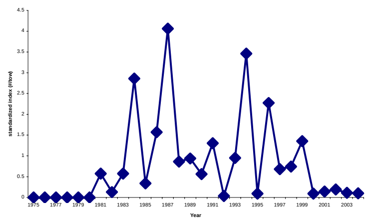


Summer cohorts

MA fall trawl survey



RI trawl survey



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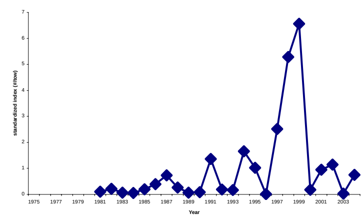
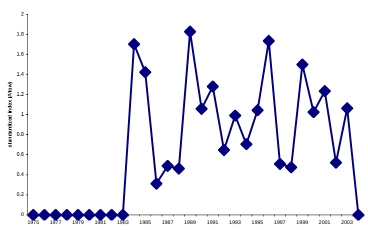


CT trawl survey



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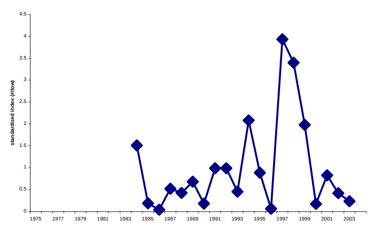
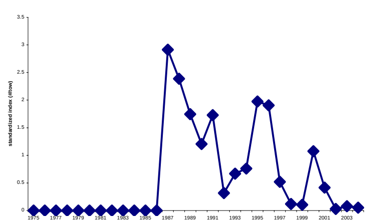
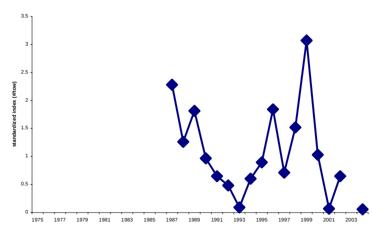


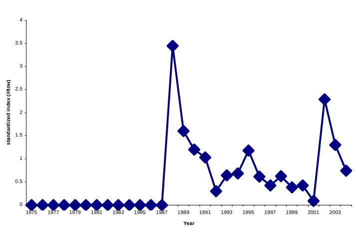
NY trawl survey



NY trawl survey



NJ trawl survey



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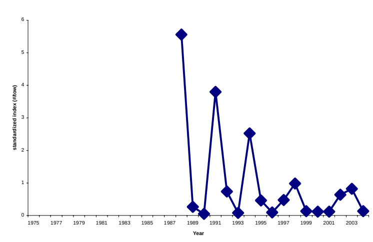
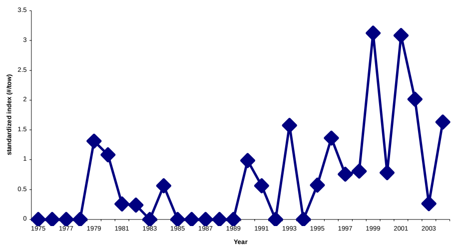


DE adult survey



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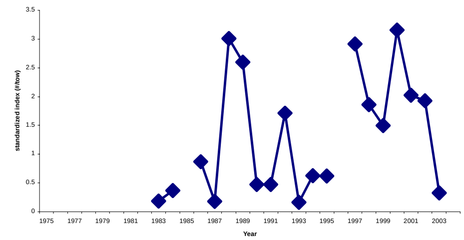
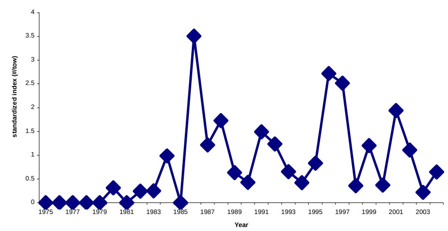


DE juvenile survey



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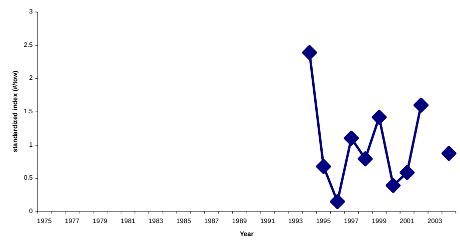
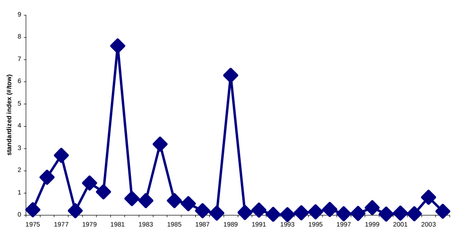
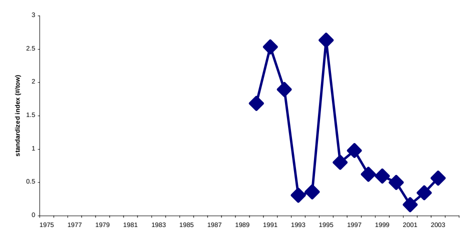


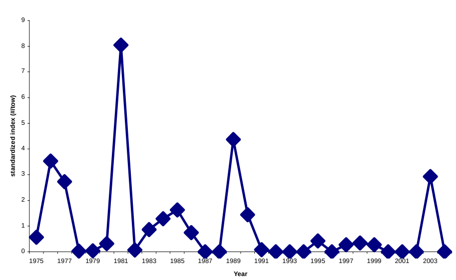
NMFS Fall inshore



SEAMAP



NMFS Fall offshore



NMFS Fall inshore

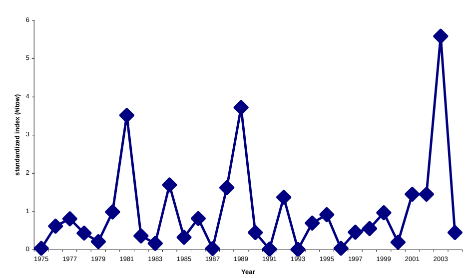
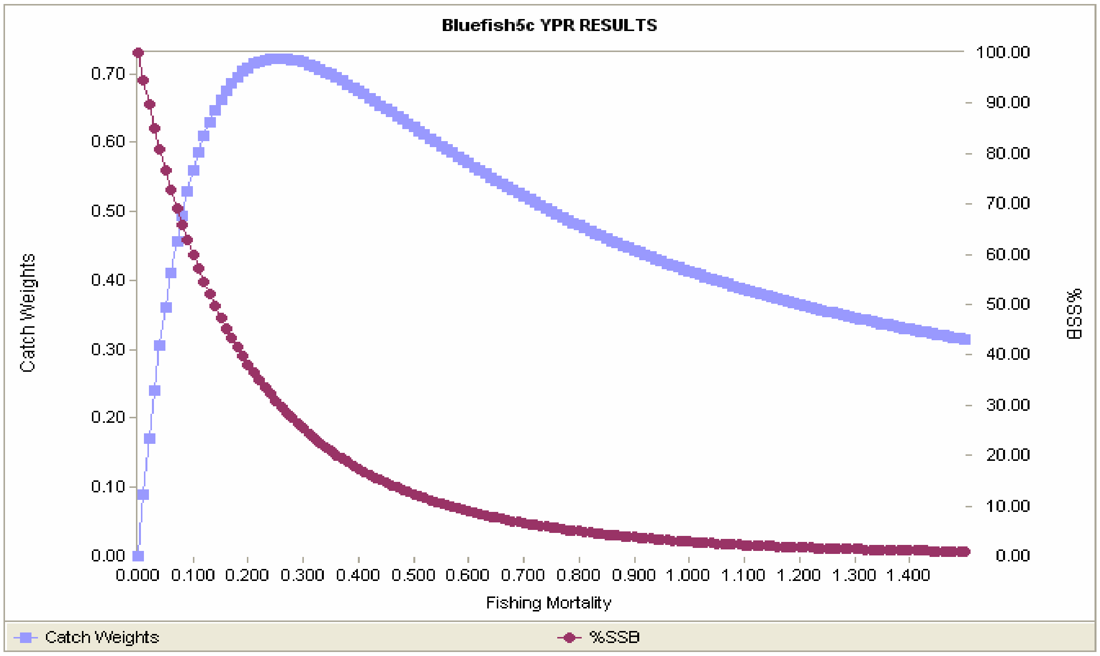


Figure 8. Age 0 spring and summer cohort by survey program, 1975-2004. Indices standardized to the series mean.



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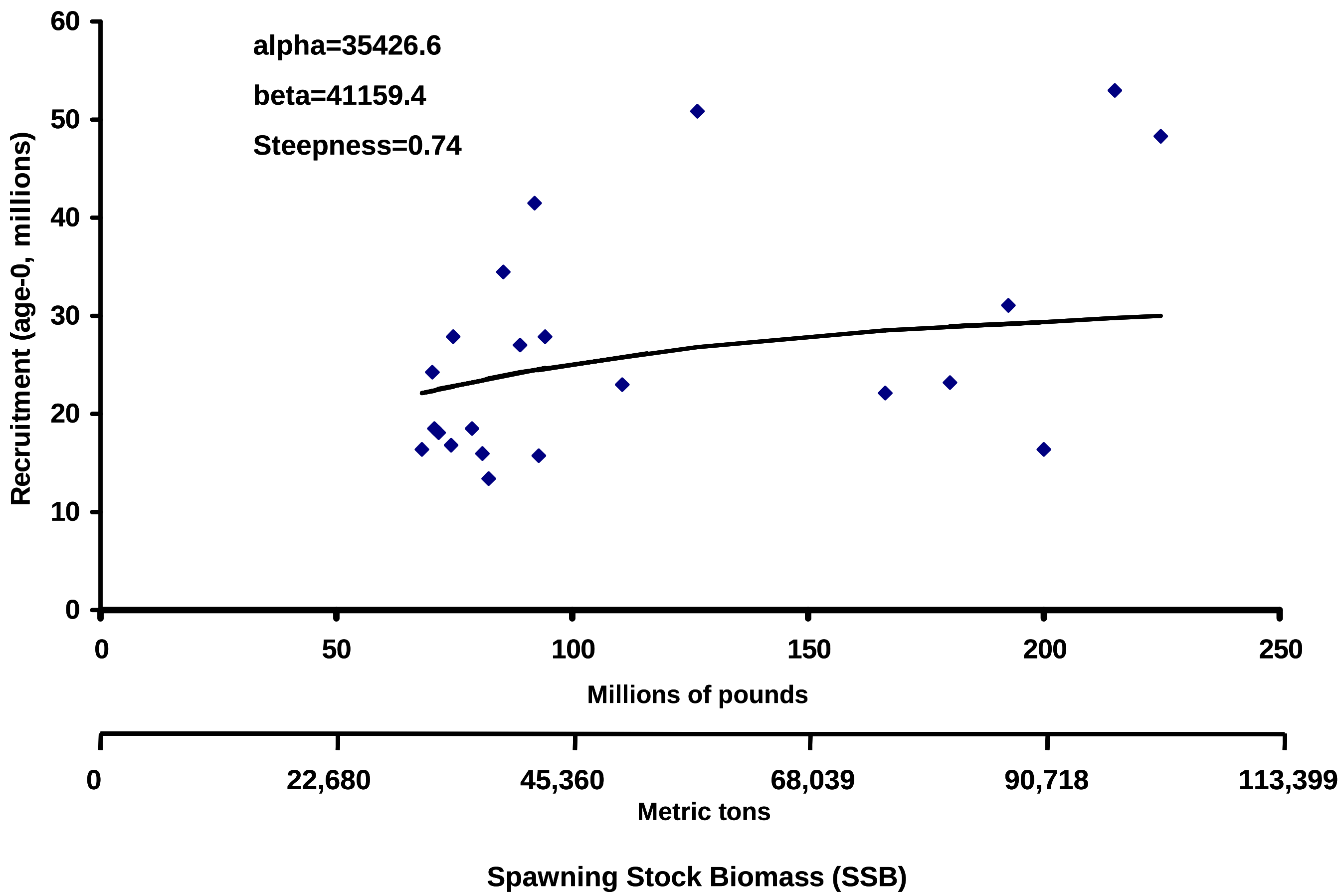

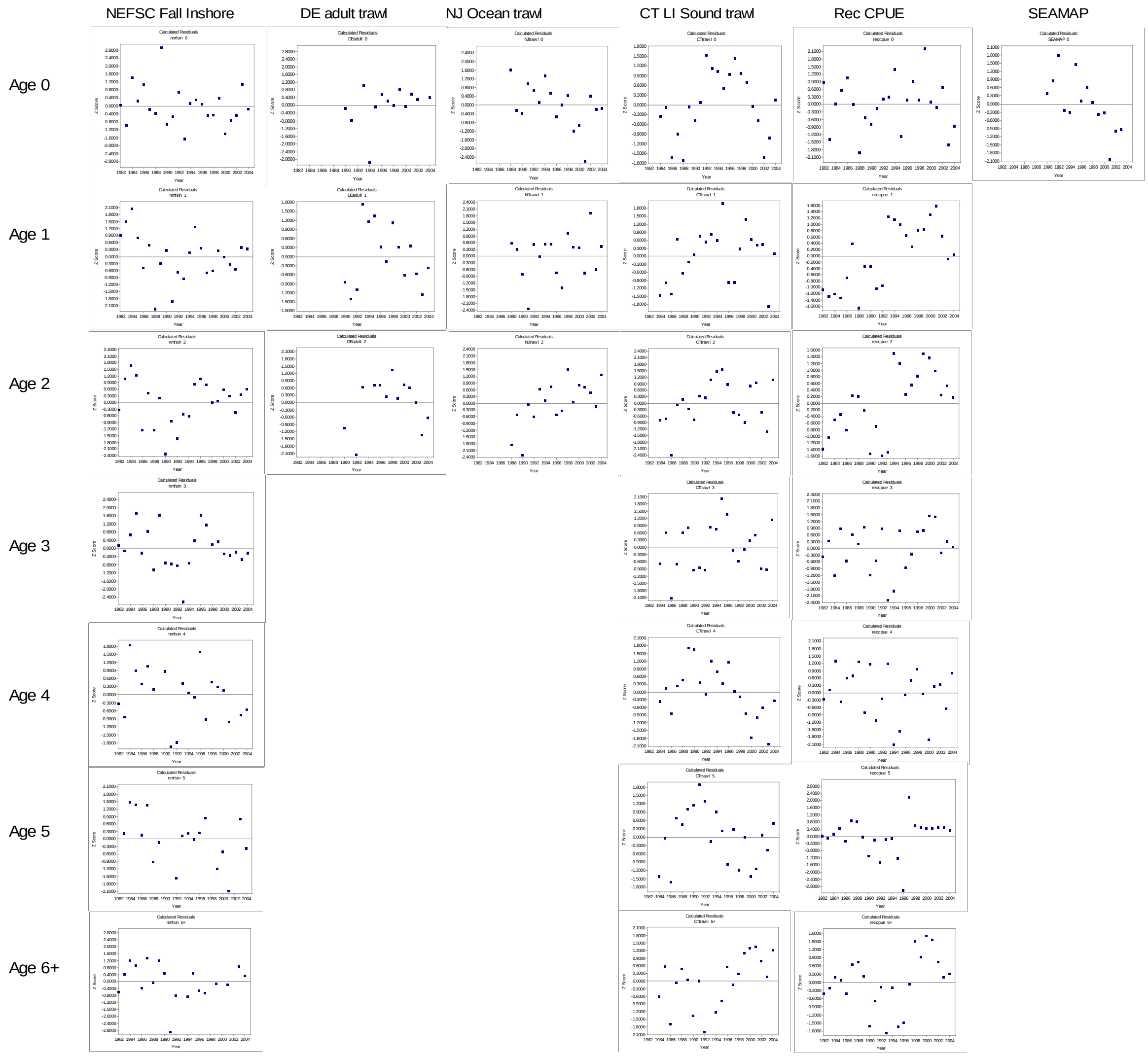

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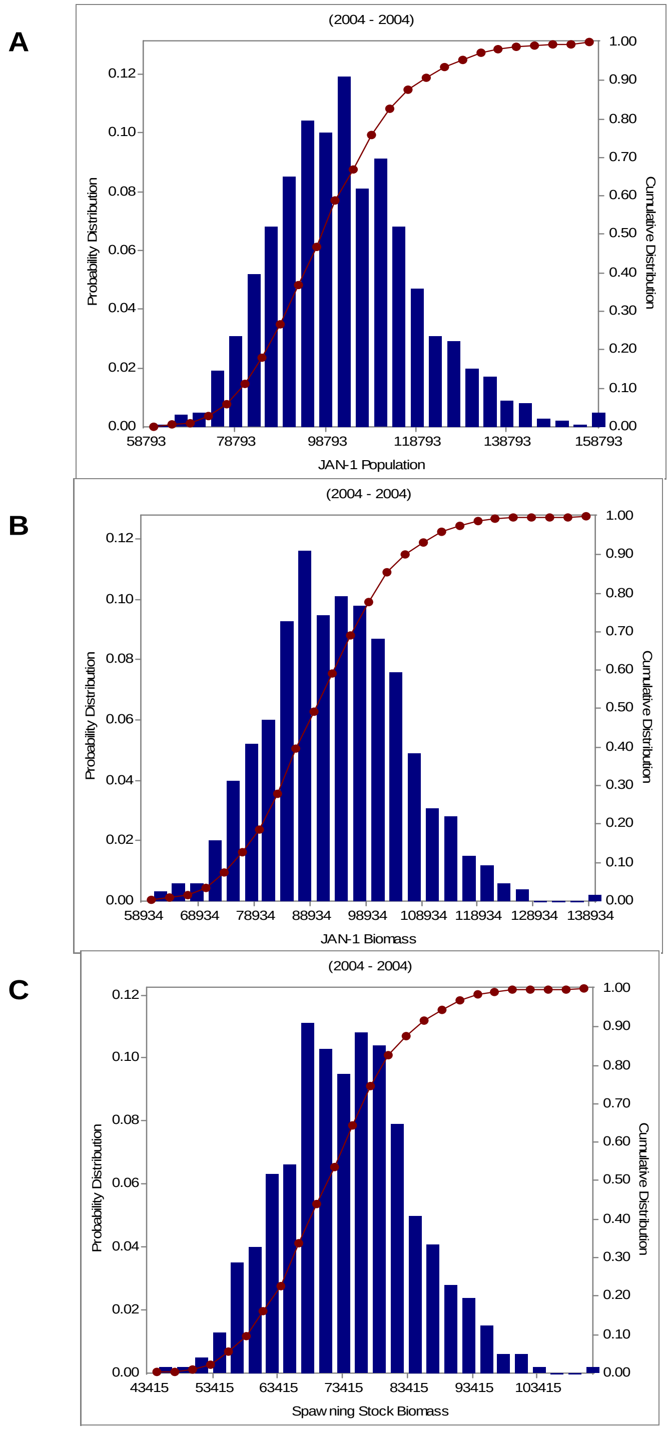

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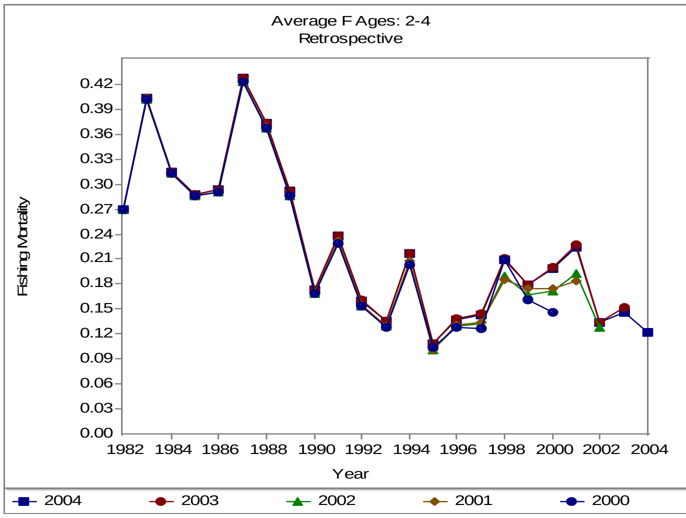


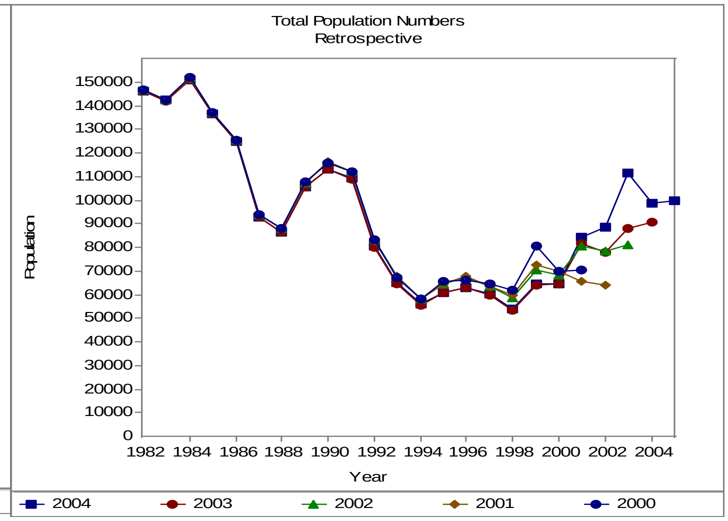


Figure 13. Results from retrospective analysis of fishing mortality and population estimates in ADAPT model.

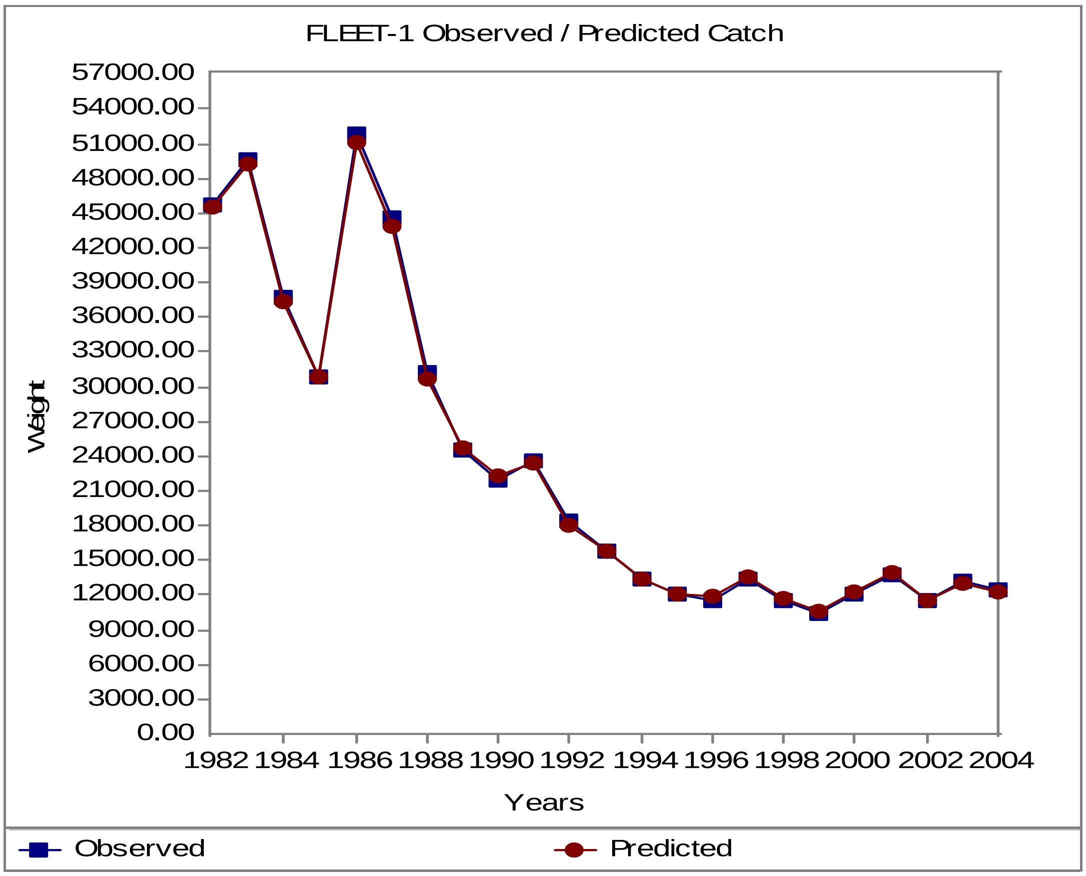
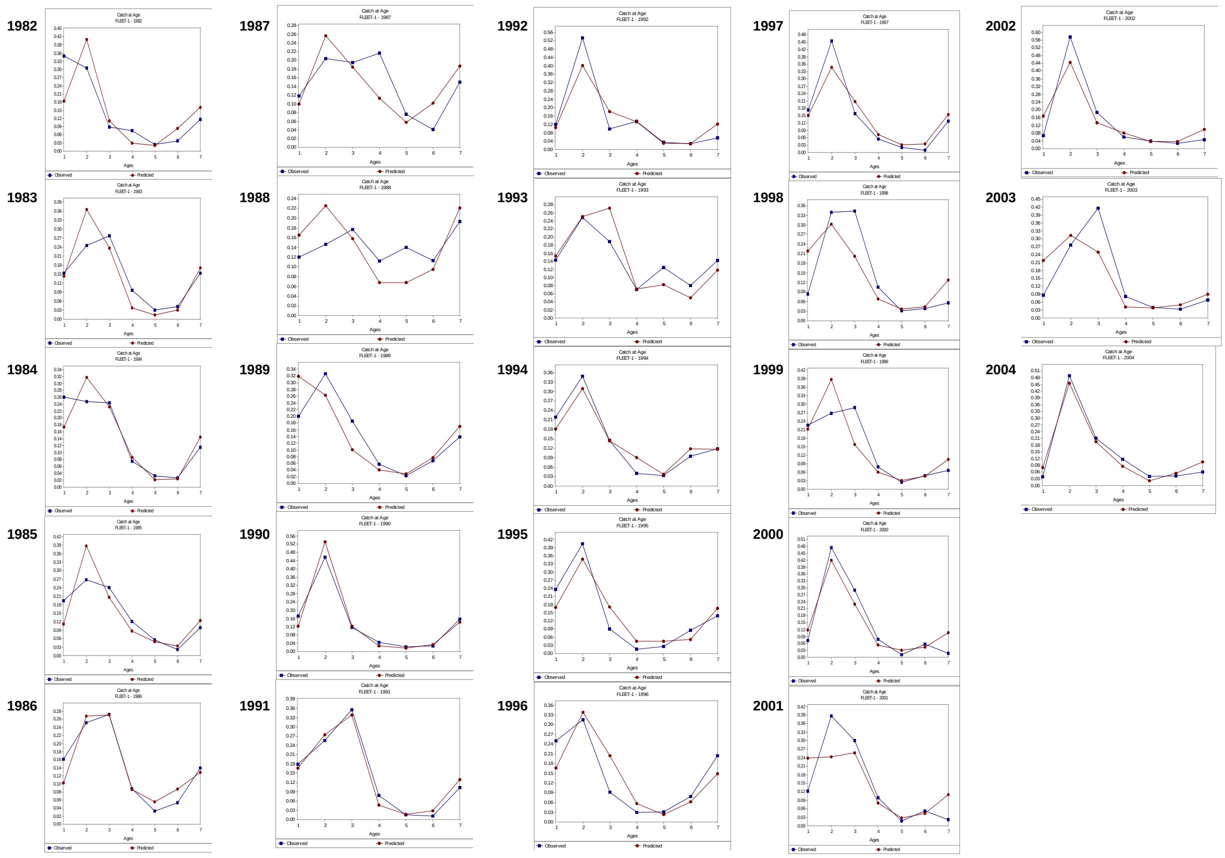


Figure 14. Predicted vs. observed annual catch at age from ASAP catch at age model.



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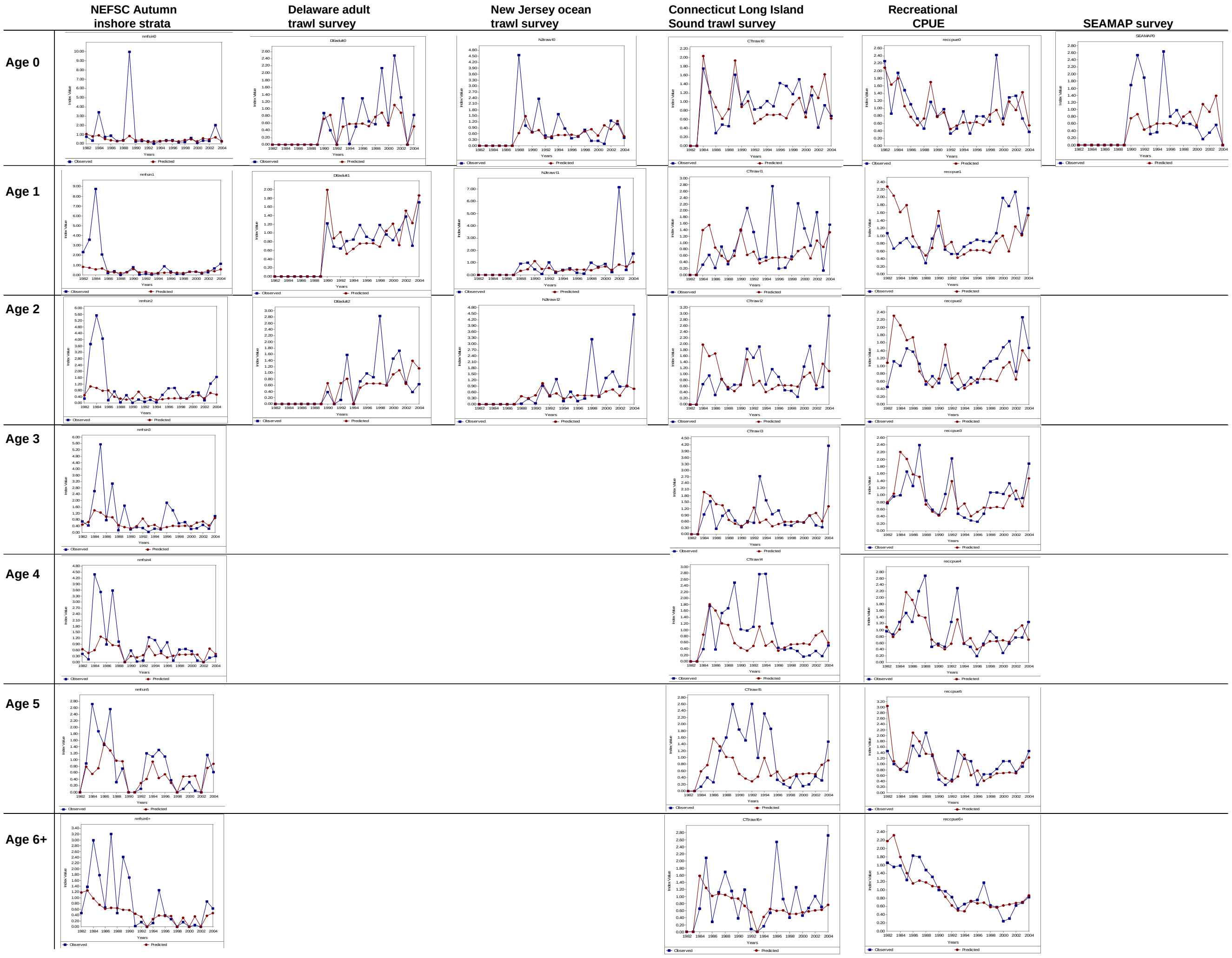
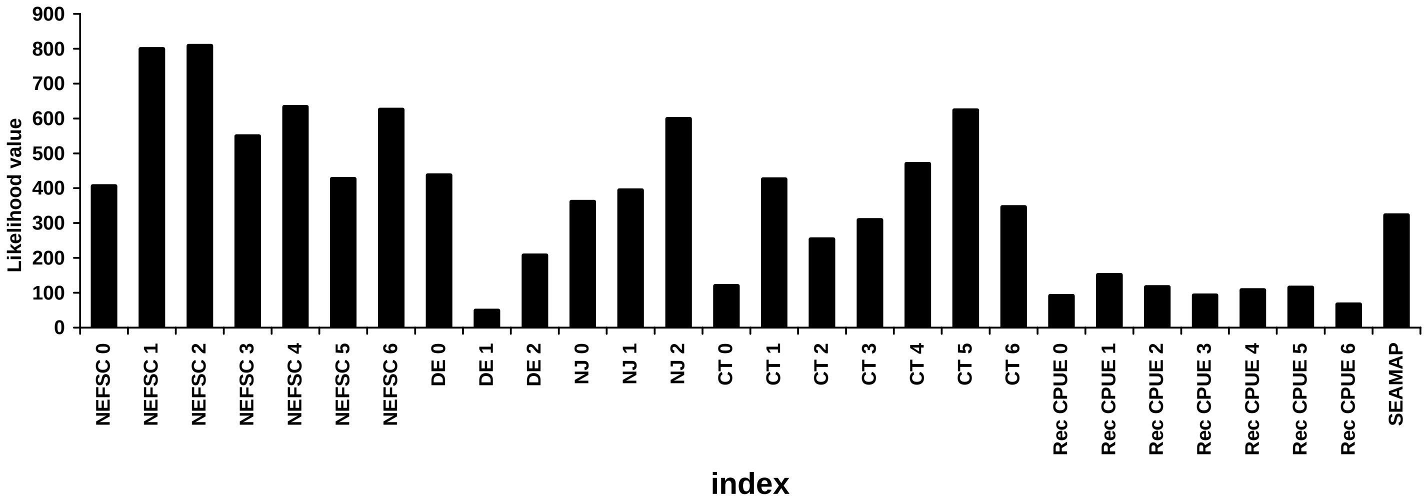


Figure 16 . Observed (blue) vs. predicted (red) indices at age by survey from the ASAP catch at age model results.



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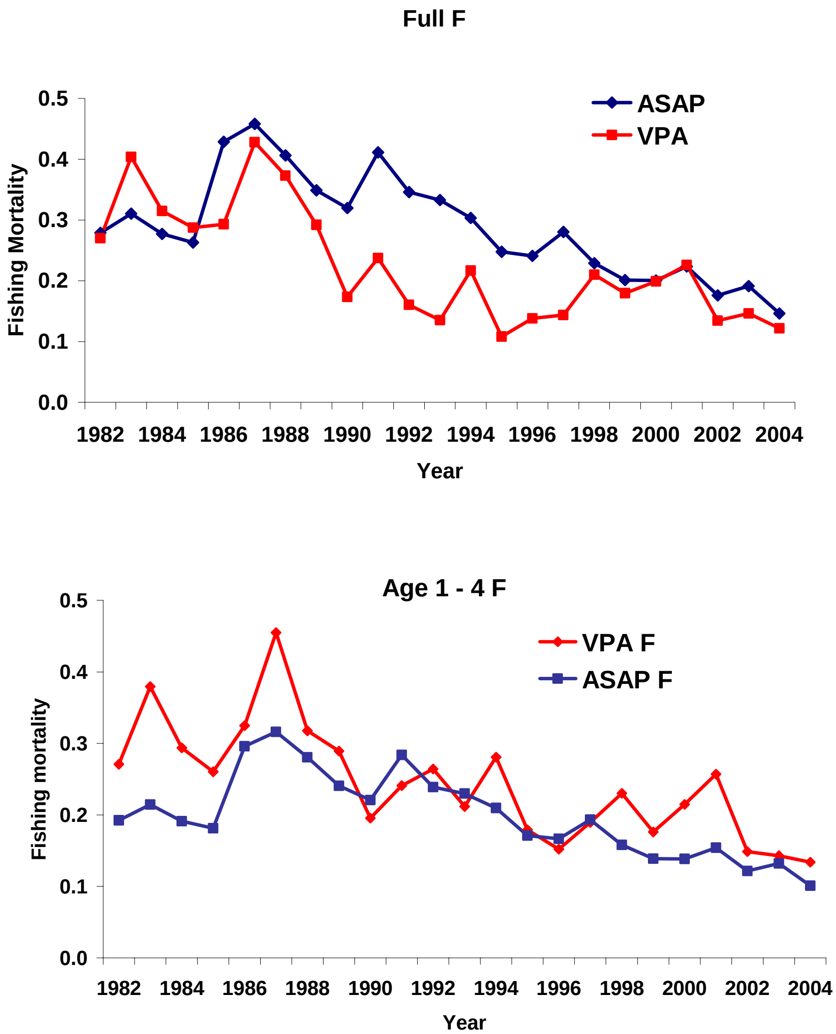

Figure 18. F_{mult} estimates from ASAP and $F_{age\ 2\text{-}4}$ from ADAPT (vpa) models. Bottom figure includes age 1 to 4 average F for VPA and ASAP.

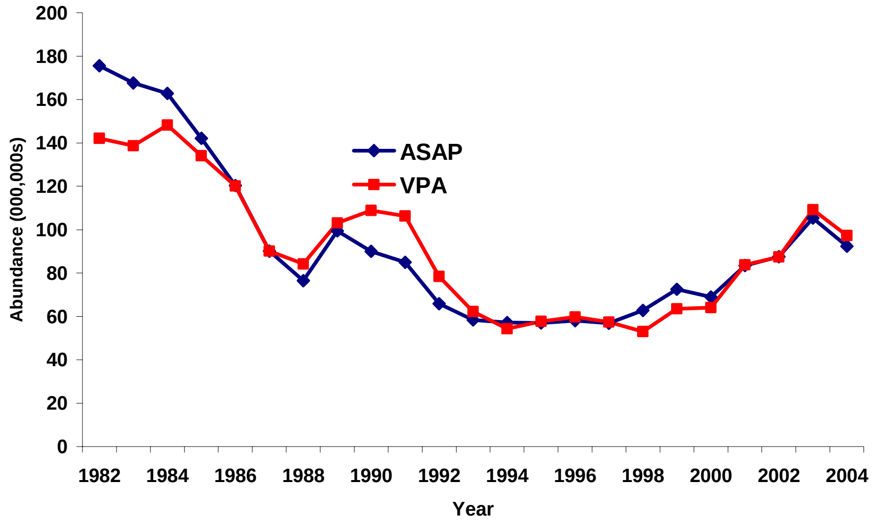

Figure 19. January 1 population abundance estimates from ASAP catch at age model and ADAPT VPA.

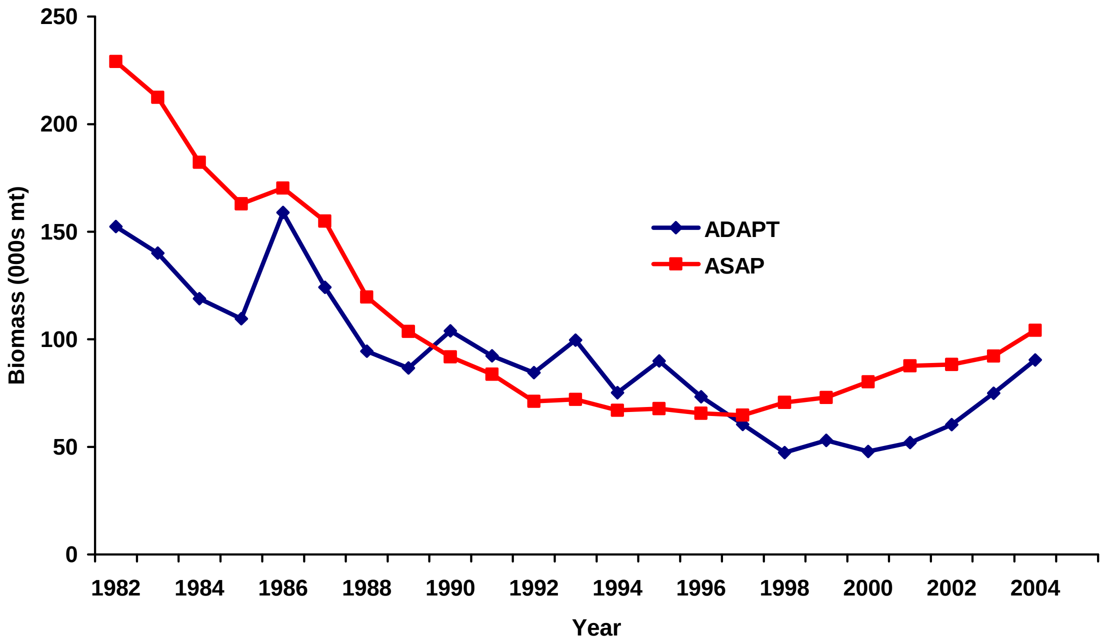

Figure 20. Biomass esimates (mt) from ASAP catch at age model and ADAPT vpa model.

APPENDIX I - Other Models Tested for bluefish

The Bluefish Technical Committee evaluated several models for their appropriateness for assessing bluefish populations. The previous assessment used a surplus production model (ASPIC) which reviewers felt produced inadequate results as structured. The shortcomings of the survey data limited the model to the recreational CPUE series as the only index with adequate spatial coverage and size distribution. A re-examination of the model using this correct CPUE series did not resolve the problems of the previous assessment. The model solution remained unstable with slight changes in the starting values. The committee chose not to use the production model in the current bluefish assessment.

Overview of Modified Delury (Catch-Survey) Model

The modified Delury or catch-survey model estimates a catchability coefficient to convert observed relative abundance indices to absolute abundance and fishing mortality rates (Collie and Sissenwine 1983; Conser and Idoine 1992; Collie and Kruse 1998). The model requires annual indices of population size in numbers for two life history stages (i.e., recruit and fully-recruited) estimated by research surveys, total annual fishery landings and discards in numbers, information on the partial recruitment of recruit size fish to the fully-recruited life stage (to partition F), and an estimate of instantaneous natural mortality. Other data needed are mean weights for each life stage and the relative selectivity of each life stage to the survey gear.

The modified Delury model is based on the equation:

$$N_{0,y+1} = (N_{0,y} + R_{0,y} - C_y)\, e^{-M}$$

where $N_{0,y+1}$ = fully-recruited stock size at the beginning of the year

$N_{0,y}$ = fully-recruited stock size at the beginning of the previous year

$R_{0,y}$ = recruitment in the previous year

C_y = catch

M = natural mortality

The equation assumes that a recruit is any animal smaller than the minimum size vulnerable to the fishery at the beginning of the survey year, and that will be fully-recruited to the fishery by the end of the survey year.

The catchability coefficient, calculated as

$$n'_{y'} = q_n N_{0y} e^{\eta t}$$

and

$$r'_{y'} = q_r R_{0y} e^{\delta t}$$

where r'_y = observed research indices of recruit bluefish

n'_y = observed research indices of fully-recruited bluefish

q = catchability coefficient of the research survey gear

$e^{\eta t}$ = log normally distributed random variable that represents survey measurement errors for recruits

$e^{\delta t}$ = log normally distributed random variable that represents survey measurement errors for fully-recruited indices

relates survey indices of abundance to absolute stock sizes.

Total mortality, Z, is estimated as

$$Z_{R+N,y} = \log_e \left[\frac{N_{0y} + R_{0y}}{N_{0,y+1}} \right]$$

Fishing mortality is calculated by solving the following equation for F

$$F = Z_{R+N,y} - M$$

or by using a harvest rate method

$$U_y = (C_y + Di) / ((R_y + N_y) * EXP(-M_y * (T_f - T_s)))$$

and then calculate F from U by trial using

$$U = F * (1 - EXP(-Z))/Z$$

where U = harvest rate

C = landings

D = discards

T_s = timing of survey

T_f = timing of catch.

Delury Data Inputs and Results

MRFSS

The MRFSS CPUE index from 1982-2003 was transformed using a negative binomial transformation for all trips that targeted bluefish and non-targeted catch, and was partitioned into an age-0 (recruit) and age-1+ (fully-recruited) index to provide a measure of encounters with bluefish where A+B1+B2 = total catch. The timing of the survey and catch during the year was 0.58, which corresponds to peak catches and landings of bluefish. Natural mortality was included as 0.20. The total removals, as coastwide landings (A+B1) and discards (15% of B2), were included along with individual weights for recruits and fully-recruited fish from the MRFSS survey and commercial and recreational removals. The bootstrapping option was set at 2000.

Results with MRFSS Data

While recruit and fully recruited indices correlated relatively well, fully recruited CPUE and catch correlated poorly. Estimates of *F* were unreasonable and produced some negative estimates over the time series. Catchability was extremely low and estimates of stock size were unreasonable with the age-0 and age-1+ stock sizes equal in some years.

NEFSC Bottom Trawl Survey

The NEFSC trawl survey from 1982-2003, calculated as a geometric mean, was partitioned into an age-0 (recruit) and age-1+ (fully recruited) index to provide a measure of encounters with bluefish. The timing of the survey was 0.75 and peak catch during the year was 0.58. All other parameters are the same as for the model runs using MRFSS data. Age-0 bluefish were split into two spring and summer cohorts, with each index paired with the fully recruited index for additional model runs.

Results with NEFSC Bottom Trawl Survey

There was weak correlation between the recruit and fully recruited indices; and indices and catch. Estimates of *F* were unreasonable and produced some negative estimates over the time series. Estimates of stock size and biomass appeared unreasonable with the age-0 and age-1+ stock sizes equal in some years. In all cases the model was not able to complete all 2000 bootstraps without error.

Modified Delury Conclusions

The Bluefish Technical Committee rejected the modified-Delury model for two main reasons. First, the model assumes that recruits are not exposed to *F* until they are fully recruited. The bluefish fishery cannot meet this assumption. Second, there are weak relationships between recruit and fully recruited indices; and between indices and catch. The weak relationships may potentially be due to *F* on recruits and weak adult index values. Most surveys are not designed to adequately sample adult bluefish.

ASPIC Model

The ASPIC program (version 5.05) was used to estimate population biomass and fishing mortality for the Atlantic coast bluefish stock. ASPIC is a non-equilibrium surplus production model that can fit several catch-effort or abundance data series and has been used in the past several bluefish stock assessments and serves as the basis for the current FMP. The results of an ASPIC model for bluefish were reviewed in SARC 39 (June 2004) and it was concluded that the model was unstable and the calibration data was inappropriate. The Technical Committee revised the fisheries-dependent and catch data series for a re-evaluation of the production model. The model was fit to the 1982 – 2004 time series of bluefish total catch from along Atlantic Coast.

ASPIC Model Calibration

Input Series

The data series used in the ASPIC model included a fishery-independent index of relative biomass and a fishery-dependent series of weight-based catch-per-unit-effort. Annual estimates of bluefish weight per tow calculated from the NEFSC fall inshore survey for the 1982 - 2004 time period provided the fishery-independent biomass index. The fishery-dependent series was generated from the MRFSS intercept and catch estimate data as described in Section 4.2.1. The re-transformed year estimates from the GLM model were used for the recreational CPUE index.

Output/Results

Parameter Estimates

The bluefish stock was modeled using 1982 as the start year. The population growth rate, r, was estimated at 0.20. Carrying capacity, K, was estimated at 4,341,000 mt. The value of maximum sustainable yield, MSY, was 219,300 mt and the corresponding biomass, B_{MSY}, was 2,170,000 mt based on the optimum model results. The fishing mortality associated with the maximum sustainable yield, F_{MSY}, was estimated to be 0.10. Fishing mortality in 2004 was estimated at a value of F_{2004}=0.12. In 2005, the starting year biomass was predicted as B_{2005}=110,900.

Goodness of Fit of Model Used

Prager et. al. (1996) provided indicators of potential reliability of the fitted model, based on measures of contrast within the data. One is a coverage index, which indicates how widely stock biomass has varied between 0 and K, the carrying capacity. The coverage index ranges from 0 (least reliable) to 2 (most reliable). The nearness index indicates how closely a modeled stock has approached the biomass level producing MSY. This index ranges from 0 (least reliable) to 1 (most reliable). The optimum fit of the bluefish biomass-dynamic model yielded a coverage index of 0.03 and a nearness value of 0.54.

Precision of Parameter Estimates

Bootstrap trials (500 times) were run to provide an indication of the bias associated with the parameter estimates. The bootstrap parameter estimates were then used to calculate 80% confidence intervals (Prager 1994). Bootstrap results indicate that model parameters were estimated moderately to poorly. For example, the bootstrap analysis suggests there is an 80% probability that MSY is between 17,170 and 484,400 mt. The value for F_{MSY} estimated by ASPIC has an 80% probability of lying between 0.049 and 0.14.

Summary of ASPIC Model

The working group felt the results of the ASPIC assessment were unreliable and not suitable to serve as the basis for management decisions. First, the ASPIC model assumed that the NEFSC autumn inshore bottom trawl survey index was representative of the available bluefish biomass, following methodology used in previous assessment work (Lazar and Gibson 2002; Lee 2003). As identified in the previous review, the NEFSC biomass index has been assumed to represent the average biomass for the respective years. The NEFSC length samples indicate that over 90% of the bluefish caught in the autumn inshore survey are less than 40-cm fork length, and therefore mostly age-0 and age-1 fish. Age samples from the commercial and recreational fisheries provide evidence that the ages observed in the fisheries are not limited to age-0 and age-1 fish (Boreman 1983; NEFSC 1994a, 1994b, 1997). As such, the NEFSC autumn inshore survey may be more suitable as a recruitment index than an index representative of the annual average fishable biomass (Boreman 1983; NEFSC 1994b). Additionally, there was a low correlation between the NEFSC index and recreational CPUE series (0.305).

There is also a lack of contrast in the catch and index data, as indicated by the low coverage index value. This points to poor information content in the data and contributes to higher imprecision of parameter estimates in the bootstrap analysis.

As a result of the problems encountered in the present iteration of the analysis, the Technical Committee dismissed the production model as the primary assessment model.

APPENDIX II – Other surveys that capture bluefish

New Hampshire

NHFG Estuarine Juvenile Finfish Seine Survey

The New Hampshire Fish and Game's (NHFG) Marine Fisheries Division developed an Estuarine Juvenile Finfish Seine Survey in 1997 to monitor the abundance of juvenile finfish in the state's estuaries. The seine survey samples fixed stations in the Great Bay Estuary and Hampton Harbor on a monthly basis from June to November. Bluefish have only been encountered in this survey during the months of July, August, and September. All of the fish were less than 21 cm in length indicating they were young-of-the-year. Significant numbers of bluefish were only observed in three years of this survey: 1999 – 76 bluefish were caught; 2000 – 7 bluefish were caught; and 2001 – 53 bluefish were caught.

New Jersey

NJDFW Delaware River Striped Bass Recruitment Survey

The NJDFW Bureau of Marine Fisheries Delaware River Recruitment Survey monitors young-of-year striped bass found from the Salem Power Plant up to Newbold Island near Trenton, NJ. The survey, which began in 1980, provides an annual recruitment index for striped bass in the Delaware River. A 100-foot beach seine samples 32 fixed stations, bi-monthly, from late June through early November. The river is divided into three regions, each characterized by a distinct habitat type. Numbers of bluefish caught for the survey season range from 7 to 194. Distribution of juvenile bluefish caught in the survey usually depends on the amount of rainfall and sizes have ranged from 31 to 338 mm FL. The highest years of abundance were 1997, 1999, and 2001. The lowest years of abundance were 1996, 1994, and 2003. The majority bluefish catches occurred in the lower part of the river.

NJDFW Delaware Bay Finfish Trawl Survey

The NJDFW initiated a trawl survey in 1991 to survey finfish occurring in the shallow waters of the Delaware Bay. Eleven fixed stations are sampled monthly from April through October. Bluefish caught in the surveys have ranged in size from 34 to 259 mm FL. The survey has caught 82 bluefish in 937 samples. Numbers of bluefish caught for the survey season range from 1 to 24.

Virginia

VIMS Juvenile Finfish & Blue Crab Trawl Survey

The Virginia Institute of Marine Science's (VIMS) Juvenile Finfish and Blue Crab Trawl Survey was started in 1955 to monitor seasonal trends of important juvenile fish and invertebrates. The survey design includes both fixed and stratified random stations, which are sampled monthly throughout the year. Sampling occurs in the Lower Chesapeake Bay and the Lower James, York, and Rappahannock Rivers.

VIMS Juvenile Striped Bass Seine Survey

VIMS started the juvenile striped bass seine survey in 1967 to monitor annual recruitment of juvenile striped bass occurring in the lower Chesapeake Bay. The survey is the second longest abundance index for striped bass in the U.S. Fixed stations along the shores of the James, York, and Rappahannock rivers are sampled monthly from July to September.

North Carolina

NCDMF Juvenile Trawl Survey

NCDMF has conducted a juvenile fish trawl survey during May and June since 1979. The survey samples fixed stations from the Cape Fear River to the mouth of Albemarle and Currituck Sounds at depths <2 meters. One-minute tows are carried out using a trawl with a 3.2 m headrope and 3.2 mm (0.13 in) mesh cod end. Indices of abundance developed from this survey using data for shrimp, croaker, and spot have shown good correlation with landings for those species, but catches of bluefish were typically low. Catches ranged from 1-20 bluefish annually and fish ranged from 4-28 cm size classes. Arithmetic mean CPUEs ranged from 0.01-0.30 (1979-2004).

North Carolina Pamlico Sound Trawl Survey

NCDMF Pamlico Sound Trawl Survey began in 1987 and was initially designed to provide a long-term fishery-independent database for the waters of the Pamlico Sound, eastern Albemarle Sound and the lower Neuse and Pamlico rivers. However, in 1990 the Albemarle Sound sampling in March and December was eliminated, and sampling now occurs only in the Pamlico Sound and associated rivers and bays in June and September. From 1987-1989, a mongoose or falcon trawl was used for comparison with SEAMAP data of inshore and offshore catches. From 1990 to the present, fifty-two randomly selected stations (grids) are sampled over a two-week period, usually the second and third week of the month in both June and September. The stations sampled are randomly selected from strata based upon depth and geographic location. There are seven designated strata: Neuse River, Pamlico River, Pungo River, shallow (6-12 ft) and deep (>12 ft) Pamlico Sound east of Bluff Shoal, and shallow and deep Pamlico Sound west of Bluff Shoal. A minimum of three stations are maintained in each strata and a minimum of 104 stations are trawled every year. Tow duration is 20 minutes at 2.5 knots using the R/V Carolina Coast pulling double rigged demersal mongoose trawls (9.1 m headrope, 1.0 m x 0.6 m doors, 2.2 cm bar mesh body, 1.9 cm bar mesh cod end and a 100 mesh tailbag extension. All species are sorted and a total number and weight is recorded for each species. For target species, 30-60 individuals are measured and total weights are measured. The two catches from each tow are combined to form a single sample in an effort to reduce variability. The total number of bluefish caught annually ranged from 26 (1995) to 324 (2004), and in length from 4-42 cm size classes. Arithmetic mean CPUEs for 2003 (2.39) and 2004 (2.34) notably higher than in previous years.

North Carolina Pamlico Sound Independent Gill Net Survey

The Pamlico Sound Independent Gill Net Survey was initiated on March 1, 2001 and field sampling began in May 2001. The primary objective of the project is to provide independent relative abundance indices for key estuarine species in Pamlico Sound and adjacent rivers that can be incorporated into stock assessments and used to improve bycatch estimates, evaluate management measures, and evaluate habitat usage. A stratified random sampling design is used and each region is divided into four areas of similar sizes. The creation of areas assured that samples were distributed evenly throughout each region. Each of the four areas by region was sampled twice a month. The SAS procedure PLAN was used to randomly select sampling grids within each area. For each of the grids selected, both the shallow and deep strata were sampled with separate gangs of nets. A gang of nets consisted of 30-yard segments of 3, 3 ½, 4, 4 ½, 5, 5 ½, 6, and 6½ inch stretched mesh, for a total of 240 yards of nets.

Segment 1 was conducted during May 2001-June 2002, and Segments 2 & 3 were conducted during July-June 2003, 2004. Excluding menhaden, bluefish were the second most abundant species encountered and only exceeded by spot. The annual index of relative abundance or catch per unit effort (CPUE) was calculated as the number of fish at length per 12-hour soak time per 240 yards (gang) of net for both regions and strata combined. The total area of each region by strata was quantified using the one-minute by one-minute grid system and then used to weight the observed catches for calculating the abundance indices. Annual weighted catch per unit effort (CPUE) estimates and weighted catch per unit effort length distributions were calculated. Bluefish CPUE was 5.87 (1,512), 3.66 (1,293), & 4.92 (1,498) during Segments 1,2,3, respectively, and bluefish were the third most abundant species collected during each segment. A wide range of size classes were represented, as bluefish caught ranged from 122-765 mm FL.